1985

NASA
National Aeronautics and Space Administration

Resident Research Associateships

Postdoctoral and Senior Research Awards

tenable at the
AMES RESEARCH CENTER
Moffett Field, California

including the
DRYDEN FLIGHT RESEARCH FACILITY
Edwards, California

administered by the
NATIONAL RESEARCH COUNCIL

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The National Research Council serves as an independent advisor to the federal government on scientific and technical questions of national importance. Established in 1916 under the congressional charter of the private, nonprofit National Academy of Sciences, the Research Council brings the resources of the entire scientific and technical community to bear on national problems through its volunteer advisory committees. Today the Research Council stands as the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering and is administered jointly by the two academies and the Institute of Medicine. The National Academy of Engineering and the Institute of Medicine were established in 1964 and 1970, respectively, under the charter of the National Academy of Sciences.

The National Research Council has eight major divisions. One of these is the Office of Scientific and Engineering Personnel, which is charged with administering Research Associateships through its Fellowship and Associateship Programs unit.

Resident Research Associateships

Postdoctoral and Senior Research Awards

1985

OPPORTUNITIES FOR RESEARCH
at
AMES RESEARCH CENTER
Moffett Field, California 94035
and
DRYDEN FLIGHT RESEARCH FACILITY
Edwards, California 93523

administered by the
NATIONAL RESEARCH COUNCIL
2101 Constitution Avenue
Washington, D.C. 20418

Foreword

The strength of NASA Ames Research Center lies in the combination of people trained in many academic disciplines with special-purpose research facilities. It has become a multipurpose laboratory that produces technology, the basis for advances in national space and aeronautics programs, and other contemporary national objectives. The spectrum of research at Ames covers

Aeronautical Human Factors
Aerodynamics
Aircraft Control and Guidance
Biomedical Research
Biosystems
Chemical Research Projects
Computational Fluid Dynamics
Computer Sciences
Earth Science Applications
Extraterrestrial Research
Flight Systems and Simulation Research
Helicopter and Powered Lift Technology
Life Sciences Flight Experiments
Man-Vehicle Systems Research
Materials Sciences
Simulation Sciences
Space Sciences
Systems Engineering
Thermo- and Gas Dynamics

The Center was founded in February 1940 by the National Advisory Committee for Aeronautics. It consists of 365 acres and is located at Mountain View, California, on San Francisco Bay, adjacent to the U.S. Naval Air Station at Moffett Field. In 1982, the staff was made up of 825 professional research specialists and 815 administrative and support specialists.

The complex of laboratories is located about 40 miles south of San Francisco, near Stanford University. The Center is also within easy commuting distance of numerous residential communities with ex-

pressways, schools, churches, shopping, and recreation facilities. Nearby San Francisco is one of the country's leading cultural centers. The proximity of San Francisco Bay affords mild winters and temperate summers.

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Introduction

General Information

The National Research Council conducts the Resident Research Associateship Programs in cooperation with a number of sponsoring federal laboratories and research organizations approved by the Research Council for participation. In the programs, a national competition is conducted by the Research Council to recommend and make awards to outstanding scientists and engineers at the recent postdoctoral and experienced senior levels for tenure as guest investigators at the participating laboratories. These programs have been conducted with a number of federal agencies since 1954.

The objectives of the program are

- to provide postdoctoral scientists and engineers of unusual promise and ability opportunities for research on problems, largely of their own choice, that are compatible with the research interests of the sponsoring laboratories and
- to contribute thereby to the overall research effort of the federal laboratories.

These programs are intended to be analogous to fellowships, associateships, and similar temporary programs at the doctoral level in universities and other organizations. They are neither intended to be, nor to compete with, permanent professional career positions.

- A Resident Research Associate is a guest investigator, not an employee of the National Research Council or of the laboratory, and there is no obligation to either organization during or after completion of tenure.

For recent doctoral graduates, the program provides an opportunity for concentrated research in association with selected members of the permanent professional laboratory staff, often as a climax to formal career preparation. For established scientists and engineers, the program affords an opportunity for research without the interruptions and distracting assignments of permanent career positions. The participating laboratories and centers receive a stimulus to their research programs by the presence of bright, highly motivated recent doctoral graduates and senior investigators with established records

of research productivity. New ideas, techniques, and approaches to problems contribute to the overall research climate of the laboratories. Indirectly, the program also makes available to the broader scientific and engineering communities the excellent and often unique research facilities that exist in the government's laboratories.

Applications for awards will be received by the Associateship Programs office of the Research Council and will be evaluated on a competitive basis by special panels of scientists and engineers. For the 1985 program year, it is anticipated that approximately 1,000 applications will be received for the nearly 250 new awards to be made in the Research Associateship Programs.

Described in this booklet are areas of research in which Research Associateships may be awarded at the Ames Research Center (ARC). Each applicant is responsible for formulating a specific research plan on a problem that is related to the current research interests of the laboratory in which the applicant wishes to do research.

Applicants whose research interests appear to be related to one or more of the opportunities described in this booklet are advised to communicate directly with the research adivsers who are designated for those areas of research. Research advisers can provide more specific information on current research programs and available technical facilities. Further inquiries concerning research opportunities and advisers may be directed to the NASA Laboratory Program Representative:

Ms. Jeanette Remington
Employee Development Specialist
Personnel Division, MS 241-3
NASA-Ames Research Center
Moffett Field, California 94035
Telephone: (415) 965-5649

Each applicant's proposed plan of research must be approved by one of the research advisers listed herein and endorsed by the program committee of the ARC to be eligible for an award. The endorsement affirms that the proposed research problem is compatible with the laboratory's interest and that adequate programmatic support will be available if an award is offered. A written response regarding each applicant's proposed research problem must be received from the laboratory by the Associateship Programs office before an applicant will be reviewed by the evaluation panels. The Center's action on the research proposal, together with a copy of the adviser's comments, will be provided directly to the applicant by the Program Representative at the ARC. It must also be determined that the applicant is acceptable for resident status at a NASA Center.

- All applicants should note that endorsement by a research adviser

and/or laboratory, while an essential component of the application process, must not be assumed to imply or guarantee an award by the Research Council. Applicants are formally recommended for awards only after open, national competition, in which special panels, appointed by the Research Council, rank candidates on the basis of quality alone. Final ranking in order of quality and the recommendation of applicants for awards are the exclusive prerogatives of these panels, and notification only by the Research Council of an applicant's status in the competition is authoritative.

Eligibility of Applicants

Citizenship

Research opportunities in basic science and applied science and technology described in this booklet are open to all citizens of the United States.

- Non-U.S. citizens may submit research proposals in basic science areas only and must have full command of the English language. Non-U.S. nationals who become Associates must have valid visas throughout tenure. Only Exchange Visitor and Immigrant Visas are acceptable to the Research Council. If an awardee chooses to apply for an Exchange Visitor Visa, the sponsorship must be under the Research Council. If one chooses to apply for a U.S. Immigrant Visa, the Research Council will not be involved in the matter.

Education and Experience

Awardees must hold the Ph.D., Sc.D., or other earned research doctoral degree recognized in U.S. academic circles as equivalent to the Ph.D. or must present acceptable evidence of having completed all the formal academic requirements for one of these degrees before tenure may be initiated. Applicants must have demonstrated superior ability for creative research. An applicant's training and research experience may be in any appropriate discipline or combination of disciplines required for the proposed research.

Prior Affiliation with the Laboratory

A primary objective of the Associateship Programs is to provide a mechanism for new ideas and new sources of stimulation to be

brought to the sponsoring laboratory. Thus, persons with substantial recent prior affiliation with a specific laboratory may not be eligible to apply for an Associateship at that laboratory.

Substantial recent prior affiliation includes direct employment relationships either with the laboratory or with a contractor whose work is performed at the laboratory. A long-term consulting relationship with the laboratory usually makes the applicant ineligible. Research contracts with universities that provide support for graduate students and faculty performing research on the campus are not ordinarily considered disqualifying.

Reapplication

Persons who have previously held a Research Associateship may apply for another award only if a period of at least two years will have elapsed between termination of the first award and the proposed tenure of a second award. Persons who have previously applied for an Associateship, but who were not recommended for an award by the panels, may reapply after one year. Candidates who were recommended for an award by the panels, but who were not offered an award because of funding or other limitations, may reapply at any time without a mandatory waiting period.

Consideration

Qualified applicants will receive consideration without regard to race, creed, color, age, sex, or national origin.

Conditions of the Award

Regular Research Associateships will be awarded to persons who have held the doctorate less than five years at the time of application and will be made initially for one year.

Senior Research Associateships are awarded only to investigators who have held the doctorate five years or more at the time of application. Senior applicants should have research experience that has resulted in significant contributions and recognition as established investigators in their specialized fields. Awards to senior Associates will generally be for one year; however, awards for shorter periods will be considered.

Under certain conditions, extensions will be granted to allow Associates to bring their research programs to a reasonable stage of completion. An extension must not be assumed.

• No commitment on the part of an Associate, the sponsoring laboratory, or the Research Council with regard to later employment is implied or should be inferred by the offer or acceptance of an award.

These Research Associateships are tenable only at the approved, participating laboratories listed in this booklet. No period of the Associateship tenure may be spent in residence at another laboratory or institution. Associates will have the status of visiting scientists or engineers in the laboratory but will be subject to the general working conditions at the laboratory. The Ames Research Center, which provides the funds to support this program, will furnish all necessary support services, facilities, and equipment for the approved research program of each Associate.

• Although applications for NASA Research Associateships will be accepted throughout the year, they will be evaluated in competition only during certain periods. Three competitive reviews will be held in 1985. Completed applications that are postmarked not later than January 15, April 15, and August 15, and received by the Research Council not later than January 25, April 25, and August 25, will be reviewed for announcement of awards in March, July, and November, respectively. The Research Council must be advised by the ARC that the proposed research has been approved; otherwise, the Research Council will assume that the proposed research is not of sufficient current interest to NASA or that support facilities cannot be made available.

Associateship awards will be made by the Research Council. The date on which tenure of an Associateship award may begin is negotiated on an individual basis. Tenure should normally begin within six months of the award; however, the starting date may be delayed by mutual agreement of the ARC, the Associate, and the Research Council. Sufficient time must be allowed between the offer of an award and the beginning of tenure to enable the Research Council and the ARC to complete all necessary administrative procedures. The starting date cannot be later than 12 months from the date of the original award. If this condition cannot be met, a new application, including a newly approved plan of research, must be submitted to the Research Council and will be judged without prejudice in the next competition.

• While every effort has been made by the participating Center or laboratory to provide Research Opportunities of ample scope and relevance, the appearance of any Research Opportunity in this booklet does not guarantee that it will be available at the time Associateship awards are offered. Changes and/or deletions may occur following the publication of this booklet, and all opportunities are subject to

final review and approval by the laboratory and the Research Council prior to the awarding of tenure.

Stipend

A Research Associate will receive a stipend from the Research Council while carrying out the research proposed as part of the application procedure. The current stipend for a regular Research Associate is at the annual rate of $26,350. The base is subject to adjustments from time to time in accordance with general national guidelines pertaining to scientists and engineers. An appropriately higher stipend will be offered to senior Associates.

Following current salary practices in certain professional fields that are experiencing a short supply of new doctoral graduates, a stipend supplement may be allotted by the Research Council to awardees in those disciplines. For the 1985 program year, stipend supplements of up to $5,000 may be added to the basic stipend for regular awardees holding recognized doctoral degrees in engineering, computer science, and clinical space-biomedical science.

- Applicants are cautioned against entering into any agreement or understanding with individual Research Advisers or other laboratory personnel concerning additional funding or other remuneration for work as an Associate. Stipends for Research Associates are limited to the amounts and by the conditions set forth above, and any other arrangement, formal or informal, between an applicant and laboratory personnel for additional monies or other considerations is strictly prohibited by the Research Council.

Commitment

Associates must devote their full-time effort to the approved research program and must be in residence at the sponsoring laboratory during the entire period of the Associateship. No additional monetary aid or other remuneration may be accepted from another appointment, fellowship, or similar grant, except for sabbatical leave, during the period of the Associateship.

Taxes and Insurance

All Associates are, in effect, self-employed. All arrangements for payment of income taxes are the responsibility of the individual Associate. An appropriate amount, estimated to approximate the tax

liability of foreign nationals, will be withheld by the Research Council from stipends of non-U.S. Associates on Exchange Visitor Visas. Details will be provided at the time of the award. Job-related injury or death will be covered by insurance (workmen's-compensation type). A group health insurance program is required for Associates and optional for dependents.

Relocation and Travel

A suitable relocation reimbursement will be determined for each awardee. Details will be provided at the time of the award. Funds will also be made available for limited professional travel during tenure, provided such travel is recommended in advance by an Associate's research adviser at the ARC and approved by the Research Council.

Publication

Since an Associate's later scientific and technical career will be judged by others, publication in the accepted open technical literature is highly encouraged. Publications should include a statement indicating that the research was conducted while the author held a Research Associateship.

Summary of the Application Procedure

For further details on the application procedure, refer to the Instructions that accompany the application packet.

- The Associateship Programs office of the Research Council will receive all applications and supporting documents and conduct the competitive evaluation of applications.
- Detailed information on application procedures, all necessary forms, and a list of the supporting documents required are available on request from the

Associateship Programs (JH 608)
National Research Council
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

- Application materials from previous competitions must not be used.
- Submit the following to the Associateship Programs office:

  Signed Application form
  Office Card
  Research Proposal (one copy with original signature on each page)
  Laboratory/Center Review form (one set)
  Previous and Current Research form

- The above application materials must be postmarked no later than January 15, 1985, April 15, 1985, and August 15, 1985, and must be received in the Associateship Programs office no later than January 25, April 25, and August 25, respectively.
- Have the following sent directly to the Associateship Programs office:

  Official transcripts of all graduate and undergraduate credits (not required for senior applicants)
  Four Reference Reports from the respondents listed on the Application. Only official Reference Report forms may be used by regular applicants. Letters of reference will be accepted for senior applicants. Senior applicants should endeavor to include some references from individuals who are not co-employees.

- The above supporting documents must be received by the Research Council by February 15, June 1, and October 1, respectively.
- The Research Council will forward the Research Proposal to the NASA Center Program Representative, who will direct it to the appropriate research adviser indicated on the form. The research adviser will review the Research Proposal and forward it to the Center's program committee for endorsement.
- No applicant will be eligible for an award without the research adviser's approval of the Research Proposal and its endorsement by the program committee at the laboratory.
- Completed applications that have been postmarked January 15, April 15, and August 15 and endorsed by the NASA Center will be reviewed by the Research Council's panels in February, June, and October, respectively.
- The Associateship Programs office will notify applicants of the disposition of their applications in March, July, and November, respectively.
- Awards will be offered by the Research Council to the extent of available spaces and funding, and acceptances or declinations must be made to the Research Council.

The National Research Council administers NASA Research Associateships at the following NASA Centers: **Ames Research Center,** Ames/North at Moffett Field, California; **Ames/Dryden Flight Research Facility,** Edwards Air Force Base, California; **Goddard Space Flight Center,** Greenbelt, Maryland; **Jet Propulsion Laboratory,** Pasadena, California; **Johnson Space Center,** Houston, Texas; **Langley Research Center,** Hampton, Virginia; **Lewis Research Center,** Cleveland, Ohio; and **Marshall Space Flight Center,** Huntsville, Alabama.

Opportunities For Research

AMES RESEARCH CENTER
Directorate of Engineering and Computer Systems

Materials and Test Engineering

Environment-Sensitive Fracture Behavior of Metallic Materials

H.G. Nelson 44.10.15.01

Some of the deleterious consequences of a chemical environment on an engineering structure can come about through influences on fracture behavior. Under conditions of static loading, fracture in an inert environment occurs in two stages—crack initiation and rapid, unstable crack growth. An additional stage of fracture can be present in a structure under conditions of cyclic loading or in the presence of an active species such as hydrogen. This stage of fracture is termed the subcritical or slow-crack-growth stage and occurs following crack initiation but prior to rapid fracture. Under cyclic loading, this stage of fracture is the result of the mechanical action of opening and closing the crack. When an aggressive chemical species such as hydrogen is present, either internally or externally, this stage of fracture occurs because the chemical interaction is a time dependent process—time dependent because time is required to transport hydrogen from its original location and form to some point on or within the metal where it can interct with metal lattice. This form of brittlement must therefore involve reaction kinetics as related to the transport of hydrogen or its interaction with the metal lattice, as well as the mechanics of the fracture process itself. Our studies deal with all three aspects of the embrittlement process in an effort to establish an improved understanding.

The primary objective of this materials science effort is to better understand the fracture behavior of structural alloys and to apply this understanding to help develop improved life-prediction procedures. Both the crack initiation and the subcritical, slow-crack-growth stages of fracture are being investigated and characterized using a

fracture-mechanics-type approach. Of particular interest is the role of the chemical environment and its contribution to the reduced life of an aerospace structure through the occurrence of stress corrosion or corrosion fatigue. Alloys investigated include steels, titanium-base alloys, and advanced powdered metallurgical base alloys. Considerable emphasis is being placed on the importance of surfaces and surface reactions when the alloys are exposed to either a gas-phase or a liquid-phase chemical environment.

Reference
H.G. Nelson, *Treatise on Materials Science and Technology* (Academic, New York, 1983), Vol. 25, Chapt. 8.

Failure of Composite Materials

H.G. Nelson 44.10.15.02

The application of advanced composite materials to primary aerospace structures requires the development of reliable analytical and experimental methods for predicting structural failure and reliable lifetimes under realistic use environments. Life-predictive criteria for fatigue, fracture, and other failure modes need to be developed incorporating such factors as original strength and orientation of individual fibers and plies, material defects, and structural configuration (holes, cutouts, and joints). Areas of investigation include (1) characterizing the response of composite material to a particular set of environmental parameters; (2) determining fundamental mechanisms of fracture and other failure modes; (3) development of accelerated test methodology and related analytical methods for simulated service environments; (4) identifying and quantifying phenomena that contribute to the accumulation of fatigue, damage, and degradation of mechanical properties under cyclic loading; and (5) correlating microstructure and macrostructure of composites with fatigue damage accumulation of component failure.

A primary objective of this material science effort is to understand better time-dependent failure in graphite/epoxy composite laminate and to apply this understanding to help develop accelerated test methodology and life-prediction techniques. A modified superposition approach is being employed to establish the correspondences among stress, temperature, moisture, and time as variables that influence long-term durability. Of particular interest is the role of moisture in influencing the time-dependent failure behavior of complex laminates. Our aim is to develop the methodology required to eventually predict the service durability of composite structures that behave in a nonlinear viscoelastic manner.

References
M.J. Adamson, J. Mat. Sci. *15*, 1736 (1980).
E.S.W. Kong & M.J. Adamson, Polymer Commun. *24*, 71 (1983).

Directorate of Aeronautics and Flight Systems

Aerodynamics Division

Turbulent Boundary-Layer Research

D.A. Johnson J.D. Murphy 44.10.07.01

Without a better understanding of the mechanisms of turbulent boundary-layer flow, the design of aircraft and aircraft components will depend heavily on empirical techniques. In order to reduce the amount of empiricism required, both theoretical and experimental studies are bing carried out in the areas of separated and unseparated flows, two- and three-dimensional flows, steady and unsteady flows, and low-speed and transonic flows. Facilities available for experimental research include the 6-ft by 6-ft Transonic Wind Tunnel plus several small-scale special-purpose tunnels. A complete array of laser and hot-wire instrumentation is also available. Computational facilities available for theoretical work include two VAX 11/780's, the CRAY XMP, and shortly a CYBER 205.

Reference

D.A. Johnson & F.W. Spaid, AIAA J. *20*, 4 (1983).

Vortical-Flow Research

S.S. Davis 44.10.07.02

Vortical-flow research is concerned with the mutual interaction among vortices, boundary layers, shear layers, and solid surfaces. Application areas range from such microflows as transition in boundary layers to such macroflows as vortex-wave alleviation from commercial transports. Vortex-flow research is also a key element in understanding rotary-wing performance and acoustic emissions. Active research programs include the structure of turbulent vortices, vortex/shear layer interactions, vortex/wing interactions, and vortex shedding from cylinders. Experimental research is conducted in a variety of small-scale wind tunnels using advanced instrumentation and computer systems. Parallel analytical and/or computational research are also actively pursued. Opportunities are available for research in advanced experimental techniques, computer/experiment integration, and analytical computational predictive methods.

Maneuvering High-Angle-of-Attack Aerodynamics and Stall/Spin

G.N. Malcolm L.B. Schiff 44.10.07.03

Modern aircraft and missile configurations are being designed to operate over a significantly expanded flight envelope to enhance maneuverability. As a result, operational aircraft have encountered unforseen control problems when performing maneuvers at large angles of attack, leading in some cases to uncontrolled spins. Existing

aerodynamic flow-field-prediction techniques, in general oriented toward low angles of attack, are inadequate for describing the flow field around aircraft performing maneuvers at high angles of attack and in the spin regime. A related topic is the need to develop models of the aerodynamic force-and-moment system as input to the aircraft's equations of motion that are of sufficient scope to cover the range of aircraft motions and flow regimes of interest. Analysis based on concepts from functional analysis suggests that the aerodynamic reactions to motions in the high angle-of-attack regime still be synthesized from the forces and moments resulting from simpler, characteristic motions. Research opportunities involving both experimental and analytical approaches exist to improve our understanding of the aerodynamics and to develop and validate aerodynamic models applicable to maneuvers of aircraft in the high-angle-of-attack and stall/spin regimes. Restricted to U.S. citizens.

References

M. Tobak & L.B. Schiff, AGARD Lect. Ser. No. 114 (1981).
G.N. Malcolm, AGARD Lect. Ser. No. 114 (1981).

Propeller-Airframe Integration

R.C. Smith 44.10.07.04

An analytical and experimental research program has begun in support of the development of a new class of propeller-driven transport aircraft that offer substantial savings in fuel consumption without increasing travel time. The achievement of the maximum benefit will depend to a large extent on proper shaping and positioning of the propulsion system and airframe components to obtain the best possible cruise efficiency. Directed toward this end, analytical studies are required to develop nacelle-wing configurations that produce low transonic drag in the presence of the propeller slipstream. Wind-tunnel tests are also required to assess the suitability of the resulting configurations and to supplement the analytical methods where they are inadequate. Restricted to U.S. citizens.

Integrated Theoretical and Experimental Aerodynamic Predictions

R.C. Smith 44.10.07.05

Most aerodynamic flow calculations neglect certain features known to be present in real flows that often lead to results lacking in sufficient accuracy or completeness. For example, the action of fluid viscosity can cause flow separation and vortex roll-up from a lifting surface that can alter the nature of the flow and are not accounted for by linear aerodynamic analysis methods. The possiblity exists, however, to account for such nonlinear effects by making suitable experimental measurements to define the pertinent flow properties that characterize the real flow. These measurements can then be used to affect a realignment of the inviscid flow solution. Innovative ideas are required

to identify and demonstrate approaches and techniques of integrating theoretical and experimental methods in this fashion to yield a more complete prediction of the aerodynamic characteristics of aircraft components or complete configurations. Restricted to U.S. citizens.

High-Angle-of-Attack Research

L.B. Schiff G.N. Malcolm 44.10.07.06

Several fluid-dynamic phenomena of interest are observed in the flow surrounding simple bodies and wings at large angles of attack. These include the presence of the leeward-side vortex structure, the onset of vortex asymmetrics, vortex breakdown, and aerodynamic hysteresis. The interaction between transition to turbulence within the boundary layer and the asymmetry of the vortices is also of current interest. The goal of this effort is to improve understanding of these and other flow phenomena existing at large angles of attack and to improve methods of accurately predicting such flows. Research opportunities include fundamental computational and experimental studies of the nature and control of three-dimensional separated flow fields.

References

G.N. Malcolm, AGARD Lect. Ser. No. 114 (1981).
L.B. Schiff & J.L. Steger, AIAA J. *18*, 12 (1980).

Rotorcraft Aerodynamic Research

M.E. Tauber 44.10.07.07

Accurate aerodynamic techniques for analyzing the complete flow field produced by helicopter rotors in forward flight do not exist. A combined experimental and theoretical research program to provide the basic understanding for developing analytical methods to analyze helicopter flows are is under way. Emphasis is placed on utilizing experimental data to enhance and verify the development of analytical methods. Topics of interest include (1) dynamic stall; (2) rotor planform shape effects; (3) vortex-airfoil interactions; (4) three-dimensional, time-dependent, flow-field analysis; and (5) experimental test procedures. Restricted to U.S. citizens.

Transonic Flow Research

R.M. Hicks 44.10.07.08

Ames aerodynamic codes have been applied to the design and analysis of airfoil sections and wing bodies for both low-speed and transonic applications. The codes either solve numerically the potential equation invoking relaxation procedures of the Euler equations. Such techniques are time consuming and therefore finite wing design and analysis is often carried out on a relatively coarse mesh. Research is needed to find faster solution algorithms and better mesh-generation schemes for these aerodynamic codes. (Restricted to U.S. citizens.)

Aerodynamic Design by Numerical Optimization

R.M. Hicks 44.10.07.09

Ames personnel have devoted several years to the development of automated aerodynamic design codes based on numerical optimization. The codes have been applied to the design of airfoils sections and finite wings for both low-speed and transonic applications. The aerodynamic codes used with the design progams employ relaxation methods to solve the potential flow equations. Such techniques are quite time-consuming, and, therefore, finite wing design is often carried out on a relatively course mesh. Research is needed to find faster-solution algorithms for the finite difference, aerodynamic codes, and to develop advanced numerical-optimization algorithms. Restricted to U.S. citizens.

Prediction of Aerodynamic Loads and Flow Fields

R.M. Carmichael 44.10.07.10

Accurate methods are being sought for the prediction of loadings on airplanes flying at all speeds through the Mach-number spectrum. Emphasis is placed on methods that treat configurations of arbitrary geometry. Advanced studies also include definition of the induced flow fields about the airplane. This research opportunity is restricted to U.S. citizens.

Transonic Flow-Wall Interference

S.S. Davis 44.10.07.11

Significant differences in the transonic aerodynamic characteristics of scaled models in wind tunnels and full-scale aircraft in flight have been reported. Wind-tunnel-wall boundary effects have been identified as a major contributor to such differences. There exists a need to develop more refined means of accounting for wind-tunnel-wall interference effects. Major areas requiring investigation are (1) design and control of adoptive wall wind tunnels, (2) determination of boundary conditions, (3) investigation of the response of the wind tunnel to the flow field imposed by the model, (4) two- and three-dimensional transonic theory for calculating the flow fields represented by models in flows with boundary constraints using direct measurement of outer flow conditions to define boundary constraints, and (5) experimental verification of predicted wall constraints effects.

Aero-Noise Effects on Transonic Tunnel Test Results

F.W. Steinle, Jr. 44.10.07.12

Recent test results from the AEDC 10° cone, tested in a variety of wind tunnels and in flight, have shown that the transition-length Reynolds number correlates with the overall root-mean-square noise level. Analysis of traversing Preston-tube-type data from this cone in both the Ames 11-Foot Transonic Wind Tunnel and in flight indicates

a several percent difference in the effective Reynolds number between tunnel and flight for the same skin friction. The difference correlates well with overall noise level. Much more work is required to establish a reliable set of corrections to account for the aeronoise in the test environment. Basic research is needed to identify the effects of aeronoise (including frequency content) on the development of boundary-layer properties for laminar-transitional and early turbulent flows. Verification tests in both tunnel and in flight (or in a facility with flow quality commensurate with flight) are required to validate correction procedures.

Flight Systems and Simulation Research Division

Advanced Guidance and Controls System Design

H. Erzberger 44.10.35.01

Analytical research and simulation experiments are under way to develop advanced aircraft guidance and control systems for a variety of missions. Typical design objectives for these systems include minimizing fuel consumption with specified time and distance to fly (4-D guidance) and minimizing the time to intercept an evading target. The research endeavors to develop implementable on-board trajectory synthesis and guidance algorithms, which are the key to future automated flight-management systems. Analytical methods used in this research include modern control and estimation theory, artificial intelligence techniques, and differential game theory. Exceptionally promising algorithms and concepts resulting from this research are evaluated in piloted simulations and flight tests.

V/STOL and Rotorcraft Autoflight System Design and Validation

G. Meyer 44.10.35.02

Research is under way to apply techniques and concepts from automatic control theory and computer science to the development of a methodology for the design and validation of high-authority auto flight systems. Opportunities for research exist in the area of nonlinear systems. The objectives are to develop and demonstrate analytical concepts and algorithms for the design and validation of total autoflight-system software for V/STOL and rotorcraft, to demonstrate the system in flight, and to exhibit contacts with related theories by generalizing the results.

Modeling of Interaction between Aircraft and the External Environment

R.C. Wingrove 44.10.35.03

Research is in progress to understand better the nature and cause of wind shear and turbulece and their interactions with fixed- and

rotary-wing aircraft. Severe hazards such as wind shear and turbulence are a continuing problem in the operation of fixed- and rotary-wing aircraft. Analytical models describing the interaction of the aircraft with external environment are required to understand better the nature of the problems and to model better these phenomena in simulation. Both theoretical and experimental techniques using actual flight data are being used to develop improved analytical models.

Helicopter and Powered Lift Technology Division

Low-Speed, High-Lift Aerodynamics

V.R. Corsiglia 44.10.40.01

Ames has a long-term theoretical and experimental program to improve the prediction techniques for airfoils and three-dimensional wings with various high-lift devices extended. This program involves the development of appropriate inviscid aerodynamics and boundary-layer computer codes and the performance of key experiments to verify and extend the theory. The objectives of this research are two-fold: (1) to improve the theoretical prediction of the high-lift aerodynamic characteristics of aircraft and (2) to provide more rational procedures for extrapolating experimental results obtained at low Reynolds number to those anticipated at high Reynolds number. Restricted to U.S. citizens.

Effects of Wind-Tunnel Walls

V.R. Corsiglia 44.10.40.02

Further theoretical and experimental studies are needed to determine wind-tunnel-wall effects on the aerodynamic characteristics of various V/STOL aircraft configurations, with the objective of providing improved corrections for these effects on models tested in wind tunnels. The wind tunnel and flight facilities available allow a check of theoretical methods that may be developed.

Aerodynamic Effects of Propulsion Systems

D.G. Koenig 44.10.40.03

The high-energy flows caused by the propulsion system on V/STOL aircraft have a large effect on their overall aerodynamic characteristics. The ability to predict the effects of these high-energy flows on performance, stability, and control of the aircraft would be a great help in early analysis of various types. Methods of prediction developed may be checked by experimental tests in wind tunnels or in flight. It is desirable, also, in this research to extend the predictions to consider the effects of ground proximity on the flow field around V/STOL aircraft, including the resultant effects on aerodynamic characteristics and engine exhaust reingestion.

Optimal Engineering System Design

H. Miura 44.10.40.04

Automated optimization of engineering design is being utilized for a wide variety of design problems. Both linear and nonlinear programming techniques have been successfully applied to obtain solutions in the past. However, a number of challenges still exist to provide a scheme that offers a versatile and flexible interface with a wide variety of applications. Hierarchical multilevel design strategy integrated with modern data-base management systems are of particular interest. Further challenges exist in formulation and solution of hueristic decision problems, large-scale combinatorial problems, and probabilistic approaches in system analysis and design. Intended applications of the technology developed in this research effort include conceptual/preliminary aircraft design, air-transportation-system evaluations, and structural design. This research opportunity is restricted to U.S. citizens.

Rotocraft Aerodynamics, Dynamics, and Acoustics

W. Warmbrodt 44.10.40.05

A sizeable experimental and theoretical research program is being carried out to improve the flight performance, vibratory load, and vibration characteristics of advanced rotorcraft. The studies include basic investigations of the aerodynamics, dynamics, and acoustics of advanced rotor systems. Rotorcraft configurations under study include conventional and compound helicopters, tilt-rotor aircraft, and stopable rotor concepts. Details inflow measurements, blade aerodynamic load distributions, rotor/body aerodynamic interactions, and rotor acoustic signatures are studied experimentally and analytically. Rotor feedback control concepts utilizing multicyclic blade feathering to minimize rotorcraft vibration, vibratory loads, and gust response are being investigated for both helicopter and tilt-rotor aircraft.

Rotorcraft Dynamics

R.A. Ormiston 44.10.40.06

An extensive experimental and theoretical program is being carried out to examine the aeroelastic stability and forced response of advanced rotor configurations. In particular, this includes rotors without flap, lead lag, or pitch bearings. This class of rotors offers advantages in structural simplicity, but there is a related complexity in the aeroelastic behavior that is not well understood. A detailed experimental program is being developed to examine blade loading and response in forward flight as a means of seeking an improved aerodynamic model. A comprehensive theoretical program is under way that will lead to a large computer program to analyze all aspects of the behavior of helicopters. This theoretical work will be validated by comparison with results of forthcoming experiments. Challenges

exist in the development of appropriate analytical tools, computer-solution techniques, model rotor design, and measurement techniques. Restricted to U.S. citizens.

DIRECTORATE OF ASTRONAUTICS
Space Science Division

Chemical Research Projects Office

Research Studies

J.A. Parker 00.00.00.00

Research studies are being conducted in polymer chemistry, chemical engineering, and physical, organic, and computational chemistry. The major emphasis is on the development of new and/or improved nonmetallic materials that have potential aerospace applications, such as matrix resins for filament wound composites and new reinforced composites for use in experimental aircraft or space vehicles. Current research topics are (1) synthesis of polymers for exposure to extreme environments such as high and low temperatures and oxidizing or other reactive atmospheres, e.g., polystyrylpyridine, polymides, epoxies, phenolics, and phosphorylated heterocyclic polymers; (2) micro- and macrostructural characterization of polymers leading to structure-property relationships, including thermal, oxidative, and photochemical stability; (3) curing mechanisms and related chemical reactions of matrix resins; (4) mechanisms of polymer degradation that are studied by means of thermoanalytical procedures, gas chromatography-mass spectrometry, proton and carbon-13 NMR, and infrared spectrometry; and (5) polymer computational chemistry leading to predictive models for key properties as a function of structure.

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Astronomy and Astrophysics

Origin and Evolution of Planetary Systems

D.C. Black P.M. Cassen J.D. Scargle 44.10.70.01
R.T. Reynolds B.F. Smith

Theoretical studies of the formation and dynamic evolution of planetary systems are being conducted in combination with observationally oriented investigations directed toward the detection and study of other planetary systems. Studies of gravitational instabilities and their effects on accretion dynamics of rotating disks and studies

of the orbital stability of planets in binary star systems are in progress. Both ground-based and space-based instruments are being studied and evaluated to obtain evidence regarding the existence of other planetary systems.

References
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D.C. Black, Astronom. J. *87*, 1333 (1982).

Planetary Rings

J.N. Cuzzi J.B. Pollack 44.10.70.02

The structure of planetary rings and the nature of their constituent particles are being investigated in depth, both theoretically and observationally. Problems currently under study are the local and regional variations in particle-abundance size, color, and brightness of Saturn's and Jupiter's ring particles; the distribution and effects of satellite resonances in Saturn's rings (specifically the observed and theoretically predicted behavior of spiral-density waves and spiral-bending waves); the nature of the interaction between a ring and nearby "moonlets;" the nature of viscosity in any system of orbiting and colliding bodies with a range of sizes; and the origin and evolution of ring systems in general. Significant theoretical overlap exists with other ongoing research opportunities (44.10.70.01). An extensive data base is maintained of all relevant Voyager imaging observations, and facilities exist for interactive image processing and analysis. A wide variety of numerical radiative transfer codes exist for treating scattering of light and radio waves, both polarized and unpolarized, by ring particles.

References
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Theoretical and Experimental Studies of Planetary Atmosphere

R.C. Whitten, Jr. J.B. Pollack T. Shimazaki
R.E. Young O.B. Toon W.J. Borucki 44.10.70.03

Theoretical and experimental work in physics of atmospheric processes has been or is being carried out in order to resolve important problems in the structure and evolution of planetary atmospheres. Examples of studies that are under way are (1) the chemistry of the lower atmospheres of Titan and the outer planets; (2) the dynamics of the upper ionosphere of Venus; (3) the structure, composition, and evolution of the atmosphere of Titan and Venus; (4) the origin and early evolution of the outer planets and their satellite systems;

(5) the general circulation of the atmospheres of Mars and Venus; (6) radiative transfer in planetary atmospheres; (7) climatic changes on Mars; (8) preparation of experiments for entry probe in the atmosphere of Jupiter and analysis of data therefrom; (9) the physics and chemistry of clouds on Titan and Venus; (10) electrical processes in planetary atmospheres; and (11) evolution of planetary atmospheres.

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Observational Infrared Astronomy

M.W. Werner F.C. Witteborn E.F. Erickson 44.10.70.04

Opportunities exist at Ames for participation in a program of observational astronomy in both the near and the far infrared. Observations are currently being made on NASA's G. P. Kuiper Airborne Observatory and at the 60-in NASA/University of Arizona telescope at Mt. Lemmon. The Kuiper Observatory consists of a specially designed 36-in telescope mounted in a modified C-141 aircraft that operates at altitudes of 41,000 to 45,000 ft. These observatories are available for use by Ames scientists, as well as qualified observers from other institutions. Programs of observations at other facilities, such as the NASA Infrared Telescope Facility in Hawaii, are also encouraged.

Instrumentation that has been developed for use on the airborne facilities includes a Michelson interferometer for the 20-30 μm region and grating spectrometers and circular variable-filter spectrometers for the 1-14 and 30-120 μm region. Efforts in this area are largely directed toward obtaining spectral information on galactic and extragalactic objects, including the planets, comets, stars, galactic H-II regions, planetary nebulae, and galactic center, and molecular clouds. In addition, ^{3}He-cooled detector systems are available for ground-based submillimeter photometry and an electro-optic polarimeter for near-infrared wavelengths is under development. Spectrometry and photometric studies of stellar and solar-system objects have been carried out with these instruments.

Emphasis has been on the thermal-emission spectrum and the composition of evolved stars, H-II regions, molecular clouds, and nonthermal emission from quasi-stellar objects. Several observational programs are devoted to understanding the properties of interstellar grains. Solar-system studies have concentrated on the aerosol composition of planetary atmospheres and the surface composition of these objects. Areas of particular interest are instrumentation development, observational techniques, and analysis and interpretation of results.

Theoretical Astrophysics

A. Barnes D.C. Black J.D. Scargle
D.J. Hollenbach L.J. Caroff J.B. Pollack 44.10.70.05
B.F. Smith P.M. Cassen

Theoretical research in astrophysics at Ames covers a variety of topics, including infrared astronomy, stellar and galactic evolution, plasma astrophysics, extragalactic astronomy, and hydrodynamics. Theoretical studies of H-II regions, molecular clouds, dusty nebulae, and circumstellar shells are being carried out by several researchers. Physical processes in interstellar shock waves and accretion shocks around protostars are being investigated with special emphasis on the infrared emission from the shock-heated gas, and the processing of dust grains in shock waves. Several theoretical projects involve the formation and destruction of interstellar dust grains, as well as their optical and chemical properties. Numerical studies of the collapse of rotating, magnetic protostars will be carried out using a fully three-dimensional hydrodynamic code that has been developed to study a number of astrophysical fluid-dynamic problems. Data from the observational infrared program (44.10.70.04 above) are analyzed using a variety of techniques. A fully three-dimensional self-consistent particle code has been developed to investigate several problems in galactic dynamics. Numerical experiments are being utilized to study the formation and evolution of galaxies, galaxy clusters in the early universe, the dynamical consequences of galaxy interactions, and the stability of disk galaxies. A detailed study of physical processes in mass loss from compact objects (stars, galactic nuclei, and QSO's) has been undertaken and is presently being applied to understanding the acceleration of matter to high velocities. A new procedure for time-series analysis of random processes has been developed and used to understand variability in QSO's, radio and other galaxies, X-ray sources, and many other objects. Research in a variety of areas of plasma astrophysics continues at both the fundamental and applied levels. Stability considerations are being used to investigate the nature of turbulent transport of angular momentum in gaseous disks. See related opportunity 44.10.70.12.

Reference

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Planetary Astrophysics

R.W. Boese C. Chackerian, Jr. 44.10.70.06
F.P.J. Valero D. Goorvitch

A laboratory program exists at Ames to measure basic molecular parameters such as rotational-line intensities and line half-widths of gases that are known or expected to be present in the atmospheres of the planets. The laboratory program is supplemented by studies that combine laboratory and observational data to deduce properties

of planetary atmospheres. Fourier-transform interferometers, capable of resolutions of up to 0.0026 cm^{-1} in the 1-100 MUm spectral region, as well as a tunable-diode laser (resolution 0.0001 cm^{-1}), are available for experimental work. Multiple-traversal absorption cells (base path up to 25 m) that can be heated or cooled are used in conjuction with the above instruments to obtain the high-resolution spectral information needed for the interpretation of observational data.

At the present time, molecular species under study include C_2H_2, C_2H_4, CH_3D, C_2H_6, C_3H_8, H_2O_2, $CFCl_3$, HCl, PH_3, GeH_4, etc. that are of interest for planetary astrophysics, including the Earth's stratosphere.

References
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C. Chackerian, Jr., & G. Guelachvili, J. Mol. Spectros. *97*, 316 (1983).

Search for Other Planetary Systems

D.C. Black J.D. Scargle W.J. Borucki 44.10.70.07

A new program has begun with the objective of searching for other planetary systems. The program involves both observational and theoretical studies. Theoretical studies related to the formation and evaluation of planetary systems, as well as to the analysis and development of data-reduction algorithms, are being conducted. Also involved are studies of instrument concepts that might be used, either in space or on the ground, to search for other planetary systems. In particular, a new scheme for improving astrometric accuracy using a multianode microchannel array detector is being tested. See related opportunties 44.10.70.04, 44.10.70.05, and 44.10.70.01.

References
D.C. Black & J.D. Scargle, Astrobphys. J. *263*, 854 (1982).
W.J. Borucki & A.L. Summers, Icarus *58*, 121 (1984).

Atmospheric Science

Theoretical Stratospheric Studies

R.C. Whitten, Jr. J.B. Pollack T. Shimazaki 44.10.11.01
R.E. Young O.B. Toon

A program for investigating the chemical composition and radiative characteristics of the stratosphere and mesosphere is under way at Ames. This program is composed of two parts: (1) a modeling effort that seeks to explain the observed composition in terms of transport and chemical processes and to determine the climatic effects of stratospheric aerosols and (2) an observational effort for measuring composition and sampling aerosols in the lower and middle stratosphere.

The model portion of the program has resulted in one- and two-dimensional time-dependent models of the minor constituents, which have been used to investigate the distribution of various minor constituents, such as ozone up to 90-km altitude. The models have also been used to study the effects of these distributions of emissions from SST's and solid-fueled rocket engines and of halocarbons from spray cans. A three-dimensional spectral model that includes the interactions of dynamics, radiation, and chemistry is currently under development. Because the radiative scattering properties of stratospheric aerosols are very important to climatic conditions on the earth, studies are being carried out to quantitatively evaluate such effects. This investigation has resulted in measurement of the optical properties of volcanic rocks and ash and sulphuric acid toward the development of an appropriate radiative transfer model and to an application of the model to climatic effects of aerosols from SST's, solid-fueled rocket engines, volcanic eruptions, and development of predictive one- and two-dimensional models of the stratospheric sulfate layer.

References

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L.A. Capone *et al.*, Geophys. Res. Lett. *10*, 1053 (1983).

Aerosol Measurements and Analyses

P.B. Russell V.R. Oberbeck 44.10.11.02
G.V. Ferry K.G. Snetsinger

Both tropospheric and stratospheric aerosols are being studied using a variety of *in situ* detection, collection, and laboratory analysis techniques. The goal of the program is to advance understanding of how aerosol properties (e.g., size, composition, and shape distributions) evolve and of their implications for atmospheric radiation, climate, and biogeochemical cycles. The approach is to develop and fly a variety of instruments on the aircraft (e.g., U-2, ER-2, and CV-990) based at Ames and to (1) intercompare results as a means of establishing confidence limits and advancing measurement technology and (2) interpret results with respect to current questions on atmospheric chemistry, dynamics, and radiation.

Wire impactors are used to collect particles for laboratory analysis using scanning electron microscopes, energy dispersive X-ray analyzers, transmission electron microscopes, an X-ray diffractometer, electron microprobes, and mass spectrometers. A gas-injection quartz-crystal microbalance cascade impactor is being readied for similar collections and analyses. A multifilter sampler collects samples for laboratory chemical analyses of sulfates and other constituents (e.g., silicates, nitrates, and chlorine). A particle-size spectrometer uses laser light scattering to yield real-time particle-size distributions in flight. A multichannel heated inlet for this spectrometer is being

developed to provide real-time chemical-composition information. Other techniques such as real-time ion chromatography and mass spectrometry are being considered. Artificial intelligence techniques are being developed for automated analysis of electron microscope images.

In addition to the analyses mentioned above, curve-fitting techniques are used to describe the multimodal nature of particle-size distributions and to relate results of different measuring devices. Results are combined to describe a unified picture of the evolution and radiative effects of events such as the El Chichon volcanic eruption.

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Atmospheric Trace-Gas Measurements

J.F. Vedder 44.10.11.03

Trace-gas measurements are a continuing effort in the Ames Atmospheric Research Program. Minor constituents of interest are halocarbons, hydrocarbons, sulfur gases, N_2O, CO, and others. A technique of cryogenic trapping of large volumes of stratospheric air has been developed in a sampling system mounted in the instrument bay of the NASA U-2 aircraft. The recovered samples are analyzed with a ground-based gas chromatograph. Concentrations of minor constituents have been measured as a function of altitude and latitude in the lower stratosphere in various locations in the northern hemisphere. There has also been a modest effort in measurements at higher altitudes (middle stratosphere) using a modified cryogenic sampling system in a balloon-borne platform.

An airborne, microprocessor-controlled, gas chromatograph system has been developed and constructed for in-flight measurements of minor stratospheric constituents. This system provides added capability for making a greater number of measurements per flight than with the cryogenic collection system and in addition carries an ozone analyzer.

Part of the present research program is directed at investigations in transport and troposphere-stratosphere exchange processes. The experimental effort involves trace-gas measurements in the lower stratosphere (e.g., Freon 11, Freon 12, N_2O, CO, and CH_4). These studies involve participation in joint experiments designed to provide experimental data on trace gases and simultaneous meteorological data on the same air mass in the intertropical convergence zone (ITCZ) and other meteorologically active regions. The measurements of trace gases provide supportive evidence in the investigations of the nature of the processes occurring in the region of the ITCZ that may be important in troposphere-stratosphere exchange.

Another part of the research involves measurements of stratospheric sulfur gases, the precursors in the formation of aerosols, as part of a multiexperiment program studying aerosols and their climatic effects. This work included several stratospheric sampling flights into the plume from Mount St. Helens and investigations of the volcanic cloud from El Chichon.

Measurements of tropospheric trace gases play a large role in this program. Information on the behavior and variability of trace-gas species in the atmosphere aids in understanding the natural atmospheric chemical processes. Currently, CH_4 and CO are determined by gas chromatography, and CO is also determined by infrared absorption. Techniques for collection and measurements of more hydrocarbon and sulfur gases are being developed.

References
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Atmospheric Radiation and Remote Measurements

F.P.J. Valero P.B. Russell W.L. Starr 44.10.11.04

Several radiometers have been developed and used to perform radiative flux and flux-divergence measurements. These instruments use state-of-the-art electrically calibrated absolute radiometers and silicon photodiodes to make both broad- and narrow-band measurements from the ultraviolet through the infrared. They have been flown on the NASA CV-990 and the NOAA P-3 in missions to study the radiative impacts of the El Chichon volcano and the arctic haze. Other radiometers have been proposed to study the properties and effects of cumulus clouds and their cirrus anvils. These radiometers will fly on the U-2 or ER-2 high-altitude aircraft; one such radiometer is near completion. A new radiometer (sunphotometer) is being developed for the CV-990 to measure the intensity of the direct solar beam in narrow spectral intervals; both external tracking and nontracking designs are being compared in ground-based tests. Data from the airborne instrument will be used to derive vertical profiles of water vapor and of aerosol spectral optical depth and to infer aerosol moments (e.g., volume and area) and size distributions.

This program is supported by an active laboratory spectroscopy program that measures basic parameters such as rotational-line intensities and line half-widths of atmospheric molecules. See opportunity 44.10.70.06.

Reference
F.P.J. Valero *et al.*, Appl. Opt. *21*, 831 (1982).

Climate Studies

J.B. Pollack O.B. Toon R.E. Young 44.10.11.05

Studies of natural and anthropogenic influences on the Earth's climate include (1) modeling of atmospheric motions and the influence of

changes in atmospheric trace constituents such as CO_2 and ozone on climate; (2) modeling of atmospheric radiative transfer and the influence of particulates such as volcanic debris, tropospheric aerosols, and water clouds on climate; (3) experiments (lidar, etc.) to measure properties, particularly composition, of atmospheric aerosols (use of aircraft as experiment platforms is emphasized.); (4) studies of solar-terrestrial relationships that could lead to climate change (studies follow the influence of solar events by imposing external forcing functions on atmospheric models); (5) application of planetary atmospheric studies, e.g., Venus and Mars, to Earth's climate (studies concentrate on climatic changes that occur over periods from 1–100 yr and longer rather than on short-term changes); and (6) investigations into the development of a parametric global model of regional climate.

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J.B. Pollack & J.N. Cuzzi, J. Atmos. Sci. *37*, 868 (1980).

Meterological Studies

E.F. Danielsen R.E. Young 44.10.11.06

Researchers at Ames are involved in a comprehensive program investigating the meteorology of stratosphere-troposphere exchange. There are three major components of this effort. First is the development of diagnostic techniques for prediction and post-analysis of radiosonde data for exchange experiments conducted by Ames researchers. These techniques will allow the calculation of self-consistent synoptic-scale potential vorticities and vertical winds over the entire globe from original radiosonde and NMC data. Second is the analysis of aircraft data from two recent tropical stratosphere-troposphere exchange experiments and from future experiments to be conducted in 1984 and 1986. Third is the development of a mesoscale modeling capability for studying fluid dynamical mechanisms for stratosphere-troposphere exchange.

The diagnostic work is well under way, and preliminary results indicate the presence of substantial drags on the time-averaged zonal winds in the upper troposphere and stratosphere. The tropical data analysis work has led to a number of important results including (1) a conceptual model of cumulus cloud mass transport into the stratosphere supported by aircraft measurements of temperature, water vapor, and ozone within a cumulus anvil; and (2) evidence of lower stratospheric turbulent mixing induced by upward propagation of large-scale waves. The mesoscale modeling is just beginning, and problems to be investigated include (1) stratosphere-troposphere exchange associated with midlatitude cyclone events, and (2) tropical stratosphere-troposphere exchange associated with barotropic unstable waves and upward-propagating, large-scale gravity waves.

Fast *In Situ* Atmospheric Sensor Development

M. Loewenstein 44.10.11.07

A variety of atmospheric problems require fast, specific detection of atmospheric trace gases. As examples we may mention (1) CO employed as a tracer of cross-tropopause mass transport and (2) study of the transport of gases of biological origin, such as CH_4, from the Earth's surface into the troposphere.

A relatively new development in atmospheric measurement is the use of tunable junction diode lasers for specific gas detection. We are engaged in a program to develop instrumentation using these tunable lasers as infrared sources and exploiting the high sensitivity of second-derivative spectroscopic techniques for specific gas detection. We are currently concentrating on the development of a CO detector for application in stratosphere-troposphere exchange studies. The CO detector will employ a laser-operating single mode on the R(6) line of the CO fundamental band at 2145 cm^{-1}. A multipass white cell is used to achieve detection sensitivities of better than one part(s) per billion by volume of CO.

Future endeavors will involve development of fast detectors for CH_4 and N_2O to be applied to surface-to-troposphere flux measurements.

Atmospheric Radionuclide Measurements

E.F. Danielsen P.B. Russell 44.10.11.08

Several projects are now underway or pending that use measurements of natural atmospheric radionuclides as indicators of air-mass origin, rates of stratosphere-troposphere exchange, and fluxes and residence times of atmospheric trace constituents. These include the use of ^{7}Be, ^{32}P, and ^{22}Na as indicators of the intrusion of stratospheric air into the troposphere; the measurement of ^{222}Rn in the lower stratosphere as an indicator of local troposphere-to-stratosphere exchange; the use of $^{210}Bi/^{210}Pb$ ratios to determine aerosol residence times in the lower troposphere; and a study of the utility of stratospheric $^{210}Po/^{210}Pb$ ratios as an indicator of volcanic influence.

Samples are collected aboard NASA's U-2, ER-2, and C-141 aircraft.

Reference

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Interplanetary Physics

Solar-Wind Theory

A. Barnes 44.10.43.01

Theoretical studies in interplanetary physics currently emphasize hydromagnetic waves and turbulence, the acceleration and heating of the solar wind, and the large-scale morphology of the solar wind.

Of special interest is the interpretation of interplanetary fluctuations as a guide to the development of the theory of hydromagnetic turbulence. Such studies require the development of new theoretical techniques for dealing with plasma-physical problems that arise in this research. In addition, detailed modeling of solar-wind flow is required for some studies. Ideas developed in the context of solar-wind dynamics may be applied fruitfully in other areas of plasma astrophysics and space physics. See related opportunities 44.10.70.04 and 44.10.70.14.

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Solar-Planetary Plasma Observations

A. Barnes R.C. Whitten, Jr. 44.10.43.02

A large body of data is available from the plasma analyzers aboard the spacecraft Pioneer 10, Pioneer 11, and the Pioneer Venus orbiter. Pioneers 10 and 11, the first probes to fly by Jupiter and Saturn, are now leaving the solar system; high-quality data is still being received. Interpretation of this data base affords a unique opportunity for progress in understanding the morphology and dynamics of the distant interplanetary medium, and, potentially, the termination of the solar wind in the local interstellar medium. The large plasma-data base from the Pioneer Venus Orbiter contains a wealth of information concerning the interaction of the solar wind with Venus. This interaction is of general importance because Venus provides the first opportunity for investigating the interaction of the solar wind with an unmagnetized planetary atmosphere, and because in some respects the interaction may be representative of the interaction of the solar wind with a comet. See related opportunity 44.10.70.12.

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Planetary Geophysics

Planetary Structure and Evolution

R.T. Reynolds J.B. Pollack P.M. Cassen 44.10.44.01

The formation, structure, and evolution of the planets and their satellites are being investigated by the construction of mathematical models and examination of spacecraft data. These studies include (1) model calculations of the interior structure and thermal history of the satellites of Jupiter and Saturn, including the effects of tidal heating and solid-state convection; (2) study of the photometric properties and geologic histories of the satellites of Jupiter and Saturn

using Voyager imaging data; (3) the gravitational-contraction histories of Jupiter and Saturn and the implications of their early histories for the compositions of their satellites; (4) the formation of planetary atmospheres during the accretion phase of formation with the objectives of determining the thermal structure of the planet, its subsequent outgassing history, and the evolution of the atmosphere; and (5) study of the geology and evolution of volatiles on Mars using model calculations and Viking imaging data.

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Space Technologies

Far-Infrared Detector Technology for Cooled Astronomical Telescopes

C.R. McCreight 44.10.78.01

Infrared space astronomy projects such as the Infrared Astronomical Satellite (IRAS) and the Shuttle Infrared Telescope Facility (SIRTF) offer high inherent system sensitivities by cryogenic cooling of telescope surfaces. A program is under way to develop and demonstrate high-sensitivity detector technology for the 2-to-200-MUm region for low-photon background observations with these telescopes. Methods such as improved materials, contacts, and electronics will be explored to reduce the noise equivalent power of discrete photon detectors to below the 10^{-17} W/Hz$^{1/2}$ level. One- and two-dimensional hybrid and monolithic arrays of detectors will be developed and evaluated under simulated and actual astronomical observing conditions. Data processing and data-base management algorithms for efficient information acquisition and evaluation of optimized detector circuitry will be included. Restricted to U.S. citizens.

Reference

C.R. McCreight & J.H. Goebel, Proc. Soc. Photo-Opt. Instrum. Eng. *331*, 9 (1982).

Cryogenic Systems and Optics Technology for Space Payloads

P. Kittel 44.10.78.02

Analytical and experimental studies are being conducted to establish the cryogenic technology required for future science payloads that operate at temperatures below 10 K. Current research opportunities/activities include (1) zero-gravity helium-3 cryostate for cooling detectors to 0.3 K; (2) adiabatic demagnetization of 0.05 K; (3) temperature gradient effects in mirrors; (4) advanced technology for cryogen storage and transfer in space; (5) long-lifetime refrigerators; and (6) computer simulation of transient and steady-state thermal performance of long-lifetime dewars. Applicants are encouraged to propose

investigations in the area of low-temperature cryogenics for space applications in addition to the above investigations. Restricted to U.S. citizens.

Fiber Optics and Optical Information Processing

J.H. Goebel 44.10.78.03

Experimental studies of the linear and nonlinear optical properties of fibers in the infrared are being purused. The goal is the development of an imaging infrared upconverter integrated with an intensified photomultiplier for photon-counting applications in the 1-to-5-MUm wavelength region. Theoretical studies of optical computation techniques are being investigated for use in high-speed computers. A two-dimensional programmable mask for Hadamard imaging is being built. Applications envisioned are the real-time control of large, lightweight space structures and ultrahigh-speed, large-matrix computations in fluid dynamics. Restricted to U.S. citizens.

Thermo- and Gas-Dynamics Division

Computational Fluid Dynamics

T.H. Pulliam H. Lomax 44.10.84.01
G.S. Deiwert J.L. Steger

The computer simulation of fluid flow phenomena is a rapidly growing field, and much progress has been made in recent years. The partial differential equations governing fluid dynamics are solved by numerical methods to yield complete descriptions of the flow field including shock waves and predictions of aerodynamic and heating loads. Research problems include both inviscid and viscous flows, two- and three-dimensional geometries, and speeds over the complete range from subsonic to hypersonic flows. The objectives are to develop research codes that solve complex flow fields with large regions of strong viscous effects, including turbulence and separation.

Computer Simulation of Turbulence

H.M.C. Yee A. Leonard M.W. Rubesin 44.10.84.02
P. Moin J.J. Kim D.G. Jespersen

Large computers are being used to carry out studies of turbulence and transition phenomena. In one approach, the time-dependent Navier-Stokes equations are solved for simple geometries with a fine spatial resolution afforded by one to three-million grid points. In another approach, combined Lagrangian vortex and Eulerian mesh techniques are used to simulate flows with large regions of separation. Objectives of the studies include a greater understanding of transition from laminar to turbulent flow, noise prediction, the statistical

description of turbulence structure, and the development of turbulence models for use in the solution of the Reynolds-averaged Navier-Stokes equations.

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Mathematical Methods for Computer Simulation of Fluid Flows

R.M. Beam R.F. Warming E.D. Martin 44.10.84.03

New mathematical methods and models are being developed for calculating fluid dynamics phenomena governed by the time-dependent Navier-Stokes equations. Fast, accurate, stable, and efficient numerical techniques are sought to provide computer simulations at high Reynolds numbers representative of flight conditions. Splitting of the finite-difference operators, implicit algorithms, and direct elliptic solvers are some of the approaches being studied. The ultimate objective is the efficient use of large computers in the simulation of fluid flow phenomena.

Applied Computational Aerodynamics

P. Kutler T.L. Holst P.M. Goorjian 44.10.84.04

During the last decade, computational aerodynamics has continued to assume an increasingly larger role in aircraft, spacecraft, and reentry vehicle design. Its overall objectives is to supply the aerospace community with more advanced computational tools to produce better designs faster and more economically. Emphasis is on providing (1) more accurate simulations of fluid physics, (2) greater flexibility in the treatment of aerodynamic configurations, and (3) greater computational efficiency. The products of this effort are numerical-solution algorithms and computer codes based on these algorithms developed with specific applications in mind. Examples of these applications include transonic flows about fixed- and rotary-wing aircraft or aircraft components, coupling of aerodynamics and structural dynamics, and supersonic and hypersonic flows of perfect or nonperfect fluids about aircraft projectiles and atmospheric entry vehicles. For a given application, mathematical formulations of the fluid dynamics are selected based on required simulation accuracy and acceptable cost. The formulations usually considered are steady and unsteady representations of either the potential, Euler, or Navier-Stokes equations. Example opportunities include the development or implementation of (1) improved numerical solution procedures (e.g., thin-layer or parabolized Navier-Stokes and zonal procedures using either explicit or implicit methods); (2) adaptive grid techniques; (3) grid-generation and geometry-definition procedures for multiple-component study of moving-body configurations; and (4) unsteady transonic aerodynamics including aeroelastic applications.

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Experimental Fluid Dynamics

J.G. Marvin M.W. Rubesin C.C. Horstman 44.10.84.05

Closely coordinated analytical, numerical, and experimental research is being conducted in subsonic, transonic, supersonic, and hypersonic flows. Particular emphasis is directed toward steady and unsteady flows with strong viscid-inviscid interactions such as those involving separation. The objective is to develop turbulence models and verify computer simulations employing either complete or approximate forms of the Navier-Stokes equations.

Experimentally, emphasis is directed toward determination of the origin and structure of turbulence and ways to model it. Current goals are to document thoroughly a series of two- and three-dimensional flows for a range of Mach and Reynolds numbers to verify and guide computational methods and turbulence models being developed concurrently. Skin friction and heat-transfer gages, hot-film and hot-wire anemometers, and laser velocimeters are available. Test facilities include the Ames 3.5-Foot Hypersonic Wind Tunnel with a Mach range from 5 to 10, and a High Reynolds Number Tunnel operating at Mach numbers from 0.6 to 3.0.

Computationally, emphasis is directed toward developing finite-difference codes that solve the Navier-Stokes equations for the exact geometry and boundary conditions of companion experiments. Integration of proposed turbulence models with varying degrees of sophistication into the codes comprises a significant portion of the research, and close coordination with experimentalists is maintained.

Theoretically, emphasis is directed toward developing models of turbulence of sufficient generality to apply to both three-dimensional boundary layers and regions of flow separation described by the Navier-Stokes equations. Modeling with the statistical equations of turbulence involves descriptions utilizing eddy viscosity and/or Reynolds stress-modeling concepts. In addition, turbulence studies of compressible fluids employing the direct computation of the large eddy motions with subgrid modeling are being conducted. These numerical experiments will be used to provide a basis for input to statistical modeling terms that cannot be readily measured.

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Analytical Methods in Aerodynamics

G.T. Chapman L.B. Schiff M. Tobak 44.10.84.06

Research opportunities exist for applying modern analytical methods to the study of basic fluid-mechanics and flight-dynamics problems that occur in aerodynamics. Examples of potential research areas

include the application of variational principles to the study of turbulence, applications of bifurcation theory to the study of vortex flows, three-dimensional separated flows and nonlinear dynamic stability, and the use of topological methods in the modeling of three-dimensional separated flow.

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Advanced Computational Concepts

J.O. Arnold 44.10.84.07

Current rapid advances in novel computational architectures such as SIMD, MIMD, and data-flow processors require that the suitability of existing numerical algorithms be critically reexamined and new methods be developed to take full advantage of the unique characteristics of these devices. Of particular interest are problems arising in computational fluid dynamics as governed by the Navier-Stokes equations and problems in computational chemistry as governed by the Schroedinger equation. Present work in progress is analytical in nature; however, ample provisions exist for numerical tests either by simulation on the computational facilities at Ames (using VAX/780's, the CRAY-XMP, or the CYBER 205) or directly on the Massively Parallel Processor located at Goddard. Arrangements can also be made for experiments on the Denelcor HEP or other machines, as appropriate.

A complementary aspect of this research is to define the properties desired in future computer systems to enable or expedite the solutions of very-large-scale problems in the physical sciences. These properties include both the hardware elements and structure as well as the computational environment afforded to the user, such as expert systems and extensive use of sophisticated graphics to simplify problem specification, concurrent code development, and interpretation of results. Current studies are under way as a joint effort of the Ames research staff and members of the Research Institute for Advanced Computer Science.

Entry Technology

J.T. Howe 44.10.84.08

Theoretical and experimental research on planetary entry is pursued in support of NASA space activities to define the aerothermodynamic environment and develop thermal protection systems for the following: (1) advanced space transportation systems and the Space Shuttle vehicle, (2) probes entering planetary atmospheres and payloads that contain radioisotopes, and (3) aeroassisted orbital transfer vehicles.

The theoretical research includes the development of computational codes that couple the transport of mass, momentum, energy, and

chemical species to the flowfield equations about entry vehicles. Moreover, radiative transfer is included in the energy equation. Work is in progress to include the effects of thermochemical nonequilibrium. Both forebody and afterbody flows are important to define, as well as flowfields over hypervelocity lifting vehicles at angle of attack.

The primary experimental tools are the constricted arc-heated plasma wind tunnels and shock tubes. A number of plasma wind tunnels are in operational status at gross power levels up to 100 MW. New plasma generators are under development to improve their performance capabilities in terms of pressure and gross power level. The shock tubes in existence cover a wide range of attainable enthalpies and pressures; shock velocities in excess of 40 km/sec have been attained in one, while spectroscopic investigations in the vacuum ultraviolet wavelength ranges are possible in another.

Plasma wind-tunnel experimental studies directed toward characterizing the heated flows include, but are not limited to, the following: specie populations, finite rate chemistry, and interactions with ablating and nonablating surfaces. Flow-sampling, spectroscopic, and pyrometric techniques are typically employed diagnostic techniques, as are the more conventional calorimetric and pressure-sensing methods. Shock-tube research includes determination of intensity and linewidth parameters of atoms and molecules in ionized and nonionized states, measurement of radiative-heat transfer rate to forebodies and aftbodies of a spacecraft, and studies of rate chemistry during vaporization of heat shields and subsequent dissociation and ionization processes.

Experiments are carried out on various thermal-protection systems to determine features such as (1) reusability, (2) radiation equilibrium temperature, (3) internal temperature rise, (4) effects of penetrations and protuberances on behavior of thermal-protection materials, (5) thermal-shock behavior, (6) ablation-mass loss rates, (7) catalytic activity in promoting atom recombinations, and (8) emission and absorption by various gas species.

Both analytic and finite-difference computational techniques are employed to predict, for bodies entering the atmospheres of the Earth and other planets, the following: (1) surface and internal temperatures, (2) ablation mass, (3) thermal stresses in heat shields, (4) terminal velocity, (5) flight attitude, and (6) dynamic flight behavior.

Calculation of Atomic and Molecular Properties and Gas-Phase Chemical-Rate Processes

J.O. Arnold R.L. Jaffe 44.10.84.09
D.M. Cooper S.R. Langhoff

Reliable values for molecular properties such as electronic transition moments and photoabsorption cross sections as well as information on the dynamics and rates of chemical reactions are obtained by

computational techniques. Systems are generally chosen for study for which experimental data are uncertain or not available and are relevant to investigations of high-speed vehicular entry into planetary atmospheres, stratospheric chemistry, stellar atmospheres, or laser-induced chemical reactions.

The molecular properties and potential energy surfaces are obtained by the self-consistent-field plus configuration-interaction (SCF + CI) and SCF + gradient techniques. The chemical rate processes are studied by the method of classical trajectories. The molecular constants and rate constants are often obtained at reliability levels that are comparable to those from high-quality laboratory experiments.

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Theoretical Solid-State and Surface Physics

J.O. Arnold H.R. Poppa D.M. Cooper 44.10.84.10

The stability of small metal clusters and the interaction of gases with surfaces are important areas of study for the theoretical characterization of material properties. Results from work in progress in each of these areas should provide a better understanding of many interesting phenomena, such as catalysis, hydrogen embrittlement, corrosion, and monolayer growth. Ames Research Center has an outstanding computer facility with a CYBER 205 and the CRAY-XMP computer, and both are available for theoretical calculations.

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The Interaction of Gases and Metal Vapors with the Surface of Solids

H.R. Poppa 44.10.84.11

Fundamental, experimental, and theoretical investigations of reaction mechanisms and kinetics of such surface physical processes as the adsorption and desorption of gases on well-defined substrate surfaces, their chemical interaction with material surfaces, and the behavior of condensed atoms and atom clusters on surfaces are under way.

These studies depend on the availability of the most up-to-date surface analytical techniques to characterize the surfaces with respect to crystallography, chemical composition, electrical properties, and binding energies of adsorbed species. In addition to the more conventional experimental techniques of low- and high-energy electron diffraction (LEED, HEED), electron (AES) and mass spectroscopy, and work-function measurements, use is made of unique methods of very-high-resolution electron microscopy (EM) and *in situ* electron microscopy under ultrahigh vacuum conditions.

In particular, our investigations are concentrated in the following problem areas related to basic surface interaction processes: (1) heterogeneous nucleation and growth of metals on insulating, semiconducting, and metallic substrates; (2) the interaction of corroding and embrittling gases with metal surfaces; and (3) basic catalytic processes on supported metal clusters of very small dimensions.

The emphasis in area (1) is on theoretical and experimental quantitative evaluations of nucleation and growth mechanisms and on mass transport and exitaxial phenomena during the deposition of thin films of various materials under very carefully controlled deposition conditions. Very-high-resolution EM, *in situ* EM, LEED, HEED, and AES measurements are all used in this connection in an approprite combination of techniques.

In area (2), our studies concentrate on the elucidation of basic processes during the early stages of corrosion and hydrogen embrittlement of metals; in particular, we attempt to characterize the influence of lattice defects and crystallographic orientation. Ultrahigh vacuum *in situ* electron-microscopy techniques are being applied to this problem area in a unique combination of analytical methods, as well as LEED/Auger measurements for characterizing the very first stages of the gas-solid interaction processes.

Under (3), we attempt to simulate in catalytic model systems the interaction of active gases with "angstrom-size" particles of controlled dimensions, structure, and number density. *In situ* TEM experiments and correlated-step kinetics tests are being used, respectively, to study changes in particle structure and distribution, and to monitor the rate of formation of reaction products.

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Laser Photodiagnostics of Flowing Gases

R.L. McKenzie 44.10.84.12

A photodiagnostics program is in progress to research and develop nonintrusive techniques for the characterization of gaseous media in a dynamic state. In most cases, the gas will be flowing, but it may also be dynamically unsteady and thermally or chemically out of equilibrium. An anticipated common aspect of most diagnostic techniques will be the use of laser-induced photophysical and photochemical phenomena. In the near term, primary emphasis has been placed on the measurement of turbulent fluctuations in the state variables of cold transonic and supersonic wind-tunnel flows. In particular, the objective is to measure fluctuations in local density, temperature, and velocity vectors at a point in a three-dimensional flow field. Regarding velocity measurements, primary interest is in alternatives to the highly developed use of laser Mie scattering from microparticles in the flow for application in situations where microparticle scattering is unreli-

able or impractical. Currently, several laser experiments are in progress. They include (1) two-photon absorption and subsequent fluorescence of simple molecules introduced into the flow to generate a rotational line spectrum and allow the measurement of temperature and density fluctuations, and (2) the development of a stimulated Raman-gain approach to determine its practical application for measuring temperatures and densities in unseeded air flows. Basic research related to the photophysics of gases is also of interest, particularly where applications to photodiagnostics are implied. Finally, new photodiagnostic techniques are sought that will lead to improved methods of velocity measurement. Candidates are being sought with backgrounds either in physics with experience in laser spectroscopy or in fluid mechanics with experience in laser applications.

This research is being conducted with the aid of excellent modern research tools including an extensive array of tunable and high-power lasers, high-speed electronics and computer equipment, and several transonic and supersonic flow facilities.

Directorate of Life Sciences

Biosystems Division

The Effects of Spaceflight on Growth and Physiology of Higher Plants

E.L. Merek J.W. Tremor 44.10.50.01

Spaceflight experiments will be designed to study the influence of gravity on plant growth and development. Information gathered in defining plant responses to weightlessness will also contribute to the development of closed biological life-support systems with autotrophic components. Studies are being conducted to specify requirements for hardware to support short- and long-term higher-plant experimentation in space.

State-of-The-Art Vestibular Research Facility for Space-Motion-Sickness Research

N.G. Daunton 44.10.50.02

A versatile state-of-the-art Vestibular Research Facility is being developed for space-motion-sickness studies and basic vestibular research. The facility will provide most of the common simulator and recording needs of vestibular research investigators (e.g., multiple axes of rotation and simultaneous application of motions about several axes, linear motion, visual stimuli, and the ability to record eye movements and electrophysiological signals). The engineering em-

phasis is in developing performance with ultra-low vibration (noise) through the use of air-bearing technology and advanced servo-control techniques. Precursor science investigations are being conducted using capabilities already developed. This facility will present a unique opportunity for research with animals and potentially human subjects concerning vestibular function, especially in the areas of semicircular-otolith interaction and visual-vestibular interaction.

Extraterrestrial Research Division

Oxygen and Early Biological Evolution

H.P. Klein 44.10.28.01

Life presumably arose in an essentially anaerobic environment. After the evolution of cyanobacterial-type photosynthesis, oxygen became available at continually increasing levels for metabolic processes. Using cyanobacteria, methanotrophs, and yeast cells for test systems, investigations are concerned with physiological effects of oxygen other than respiratory processes. Several enzyme systems that require oxygen as a metabolic substrate are being studied, including those involved in the formation of mono- and polyunsaturated fatty acids and sterols. Research is directed at understanding the role of different levels of oxygen in controlling the activity and the localization of these enzyme systems in phylogenetically diverse micro-organisms.

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Organic Cosmochemical Evolution

S. Chang 44.10.28.02

Organic cosmochemical evolution encompasses the evolutionary path of carbon and its compounds from interstellar dust clouds to solar nebulae, planetesimals, and planets and to the beginnnings of life on Earth. In the laboratory, the syntheses of organic compounds related to terrestrial biochemicals are explored in experiments that simulate the putative environments of interstellar dust clouds, cooling solar nebulae, and primordial and extant planetary atmospheres and surfaces. Knowledge of the early-solar-system history of the organogenic elements (C, N, H. S) is sought through studies of their nature, abundance, and isotopic composition in cosmic dust and carbonaceous meteorites. Research on the potential organic chemistry occurring on the outer planets and their satellites focuses on reactions initiated by hot atoms resulting from high-energy-particle bombardment and by ultraviolet irradiation of mixtures containing some or all of the gases H_2, N_2, CH_4, NH_3, PH_3, and H_2S. Insight into the stabilities, reactivities, and energetics of formation of molecules relevant to the organic

chemistry of the interstellar medium and other primordial environments is obtained by quantum chemical calculations. Plausible pathways for the synthesis of biopolymers under simulated conditions appropriate to the prebiotic terrestrial environment are being explored and the mechanisms elucidated. This program will provide (1) insight into the origin of organic matter in the solar system and cosmos; (2) support for the theory of chemical evolution and the existence of extraterrestrial life; (3) an understanding of the chemical events leading up to the origin of life on Earth; (4) data relevant to the present chemistry of the atmospheres of the outer planets; and (5) help in the design of meaningful chemical experiments for the exploration of the outer planets, comets, and asteroids.

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Studies of Carbonaceous Meteorites and Interplanetary Dust

T.E. Bunch 44.10.28.03

Research in this program combines the study of inorganic phases of meteorites and interplanetary dust by electron microprobe, scanning-electron microscope, X-ray diffraction, and petrographic microscope methods with the determination of noble-gas contents. The goals of this program are (1) to gain insight into the formational processes of meteorite constituents in terms of earliest formed grains to later interactions in or on parent bodies, (2) interpret the environmental constraints imposed by these samples on models of parent-body evolution, and (3) provide supportive data for solar-system-origin modeling.

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Global Biology

J.G. Lawless 44.10.28.04

The global biology program focuses on two issues. The first is the nature and quantity of sulfur (S) and nitrogen (N) species produced in the coastal marine environment. Among the questions to be addressed are (1) what is the relationship between chlorophyll maps of the coastal marine environment and biological productivity; (2) can this information be related to S and N flux; (3) what are the identity and quantity of the S and N compounds being produced; (4) which species of biota are producing these chemical compounds; (5) what are the chemical, physical, and biologically induced changes of these compounds at the sediment-water interface, within the water column, at the water-air interface, and in the atmosphere; (6) what is the nature of atmospheric transport and what is the ultimate fate

of the compounds; and (7) are there compounds that are diagnostic of specific biological sources? The second issue involves the effect of disturbances on the cycling of water, carbon, nitrogen, sulfur, and phosphorus in a terrestrial ecosystem. Within a California river watershed, two subsystems have been identified: cropland and forest. Among the questions to be addressed are (1) can meaningful ecosystems be discerned by remote sensing; (2) can this information be related to productivity and the cycling of the water, C, N, S, and P; (3) what is the identity and quantity of the chemical compounds being produced and how are they coupled; (4) which species of biota are producing these chemical compounds; (5) how do disturbances affect the nature and quantity of compounds released; (6) in what form are the elements C, N, S, and P returned to the system and what are the consequences for biology; and (7) are there compounds that are diagnostic of specific biological sources and the state of health of this biota? The global applicability of these findings will be accomplished through *in situ* analysis of additional sites in the U.S., in collaboration with scientists in other countries, by remote sensing, and through computer modeling.

Bacterial Denitrification and Steady-State Growth

L.I. Hochstein 44.10.28.05

Information concerning denitrification has been studied using "batch" cultures in which conditions continually change during growth. As a consequence, certain questions still exist concerning denitrification. For example, it is fairly well established that nitrate reduction proceeds by nitrite, nitric oxide, and nitrous oxide, terminating with the production of nitrogen. However, it is not clear if all the intermediates are obligatory and to what extent some may represent offshoots from the main pathway of nitrate reduction. In a similar vein, oxygen has been reported to suppress denitrification; however, contrary observations have also been made. While such discrepancies may reflect species differences, the ill-defined conditions that exist during growth in "batch" cultures (continuously changing levels of nutrients and oxygen tension, for example) could contribute to uncertainties. Therefore, it is proposed to examine denitrification during steady-state growth in chemostats, varying such parameters as the carbon and energy sources, the nitrogen source, and the oxygen and nitrate concentrations, with the aim of defining how these contribute to the process of denitrification. Of particular interest is how growth at various oxygen tensions regulates relative levels of oxygen and nitrate-linked respiration. We recently demonstrated that a CD-type of cytrochrome, purified to electrophoretic homogeneity, produces ammonia from nitrate. The microbial distribution of this novel cytochrome and its *in vivo* role are under investigation.

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Adenosine Triphosphatase Activity and Evolutionary Relatedness

L.I. Hochstein 44.10.28.06

The essential role and widespread distribution of the energy-transducing ATPases suggest they appeared relatively early during the course of evolution, although their complexity represents a level of molecular sophistication far greater than would have occurred during the early transition from chemical to biological evolution. The complexity of the enzyme (at least five subunits in the F_1 component and four in the F_0, with molecular weights ranging from about 56,000 to 14,000) suggests that the molecule should be extremely rich in information concerning the relationships between various organisms and, in particular, the bacteria. To this end, ATPases from various bacteria will be examined with respect to the number and ratio of their subunits, the interchangeability of these units, their immunochemical similarities, and their function. A particular area of interest will be to compare the ATPases from halobacteria, thermoplasma, and sulfolobus.

Intermolecular Interaction and the Origin of Life

R.D. MacElroy 44.10.28.07

A significant period of the Earth's early history is assumed to have included the formation of increasingly complex organic molecules. This period of chemical evolution culminated in the formation of organic systems that could be called life. The characteristics of life include the reproduction and maintenance of information (nucleic acids), the formation of catalysts (enzymes) with specific functions, and the evolution and diversification of systems as cells. All of these characteristics appear to be dependent upon the exchange of "information" among molecules through intermolecular interaction and noncovalent recognition.

Studies are proceeding under the assumption that the origin of life involved interactions among molecular entities that form the basis of extant life forms, such as amino acids, peptides, nucleic acids, and nucleotides. The basis of recognition among molecules is assumed to be a combination of molecular characteristics, most of which are dynamic and may change during an interaction, such as electrostatic potential surfaces and van der Waals surfaces. Because molecular interactions associated with the origin of life probably occurred in solution, the role of solvents in interactions among biomolecules is of particular interest. The techniques used to explore these problems have included *ab initio* methods to establish potentials and reaction geometries, semiempirical methods, and empirical energy calculations

on large molecular structures. Monte Carlo and molecular-dynamics techniques are used to simulate dynamic interactions.

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Ecosynthesis: Development of Controlled Ecological Systems

R.D. MacElroy 44.10.28.08

Man depends on the natural regulation and the smooth functioning of the terrestrial ecosystem for his food, his water, and the air he breathes. In contrast, small, closed ecosystems for use in space or on inhospitable planets will have to be tightly controlled and mechanically regulated if they are to provide reliable long-term sustenance of their human inhabitants.

Work in progress includes development of small, controlled systems capable of growing plants; development of models describing plant-physiology dynamics; investigation and application of control models; investigation of sensing models and sensitivity analysis; exploration of the use of "learning" algorithms for imposition of control; and the application of classic techniques for system analysis.

It is anticipated that the construction and study of a variety of ecological models will aid in development of realistic models—conceptual and mathematical as well as physical models of controlled ecological systems.

Stable-Isotope Biogeochemistry

D.J. Des Marais 44.10.28.09

Studies of contemporary biological systems constitute a powerful approach toward a better understanding of the origin and early evolution of life. Key features of these ecosystems are often expressed as stable isotopic patterns in the associated organic substances. Despite the considerable advantages of such isotopic measurements, the study of these isotopic patterns is still in its infancy. Research in progress in this laboratory includes studies of the following: (1) the origin of isotope effects in microbial intermediary metabolism, as observed in amino acids, sugars, and lipids; (2) the flow of carbon in terrestrial ecosystems as revealed by carbon isotopic measurements; (3) the origin of natural gases in marine sediments and deep wells; (4) the origin of isotope effects in extraterrestrial materials; and (5) the development of new analytical techniques to support the above investigations.

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Inorganic Chemistry in the Origin of Life

J.G. Lawless 44.10.28.10

The role of metal ions and clay in the origin, evolution, and distribution of life is being investigated. Research in progress includes (1) studies of the effect of metal ions and clays on the product distribution of laboratory-simulated chemical-evolution experiments; (2) investigations of the strength and nature of the interaction of metal ions with biomonomers; (3) the effect of energy (i.e., UV, heat) on the decomposition of amino acids and nucleotides in solution with metal ions and clays; (4) the adsorption of biomonomers on homoionic clays; and (5) the influence of metal ions and clay on polymerization processes, specifically as they affect polypeptide and polynucleotide formation.

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Advanced Life-Support-Systems Research

T.J. Wydeven 44.10.28.11

Research programs are concerned with exploring and developing advanced concepts for regenerative life-support systems for the space station and portable life-support systems for extravehicular activity. General areas of interest are removing and processing expired carbon dioxide, recycling oxygen and water, and controlling trace-gas contaminants. Research and development of advanced life-support processes are of particular importance for a space station because of the need to minimize the weight and volume of the life-support system and thereby maximize or increase the payload. Therefore, potentially lightweight and low-volume life-support processes are of special interest.

Evolution of Complex Life

J. Billingham 44.10.28.12

Studies are being carried out on the effects of events in space on the evolution of complex and higher organisms, i.e., over the past one billion years of Earth history. Specific interests are the effects on the terrestrial environment of (1) large-scale impacts of comets or asteroids with the Earth, (2) changes in the sun, (3) periodic solar-system changes (precession, obliquity, etc.), (4) nearby supernovae, and (5) passage of the solar system through spiral galactic arms. The principal question is then what effects such changes have on the evolution of complex life. A secondary question is the extent to which inferences can be drawn about the possible emergence of complex life elsewhere in the universe. Particular attention is paid to the trend toward increasing complexity and to arguments related to the emergence of intelligent species.

Gas Chromatography

G.C. Carle 44.10.28.13

Gas chromatography is one of the most powerful analytical techniques available today for gathering information on different chemical species and their concentrations in the atmosphere and on the surfaces of planets, moons, and other bodies of the solar system. As such, studies relating to gas chromatography are pursued that will extend its capabilities. Areas currently being studied include the following: (1) new concepts for highly sensitive and linear detectors, (2) new concepts for highly efficient columns and packings, and (3) ultra miniaturization of the major chromatographic components and the theoretical aspects thereof.

Productivity and Biogeochemical Cycling in Terrestrial Ecosystems

J.G. Lawless 44.10.28.14

A major goal of NASA's Biospheric Research Program is to increase our knowledge of the controls and interactions of the nitrogen, phosphorus, sulfur, and carbon cycles. Living organisms, especially primary producers and decomposers, are a focal point of interaction and perhaps control of these cycles and, as such, may hold important predictive characteristics. The questions we address include the following: (1) Can biochemical characteristics of primary producers predict rates of nutrient cycling and decomposition in terrestrial ecosystems? (2) How do different intensities of disturbance affect nutrient and carbon acquisition, turnover, and loss? (3) Can predictive characteristics of vegetation or soil be remotely sensed?

Biomedical Research Division

Studies of Amphibian Embryogenesis in Altered Gravitation Fields

K.A. Souza 44.10.21.01

Amphibian embryogenesis is known to be sensitive to alterations in the magnitude and direction of gravitational force. Research is conducted to determine the role of gravity during embryonic development and to identify the gravity-dependent processes. The utility of a zero g environment (e.g., in the Space Shuttle) as a tool of embryology is being evaluated, and problems are studied involving the fertilization, development, and rearing of amphibian embryos in a weightless condition.

Cardiovascular Effects of Weightlessness

H. Sandler 44.10.21.02

Experiments are being carried out in animal models and humans to determine the mechanisms used by the cardiovascular system to adapt to weightlessness. Studies in humans utilize bed-rest simulation, Og

spaceflight, and noninvasive or minimally invasive measurement techniques. Animals are studied using chronic instrumentation procedures and advanced implantable instrumentation packages.

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Bone Metabolism and Biomechanics

D.R. Young 44.10.21.03

Research programs are conducted to develop the restrained primate model for the study of disuse osteoporosis in hypodynamic-hypogravic environments. The studies are directed at (1) demonstrating the earliest histomorphorphologic changes in cortical and trabecular bone during restraint; (2) determining influences of losses in the spine and appendicular skeleton on bone rigiditiy and strength; (3) elucidating electrolyte losses in relationship to skeletal status; (4) correlating indirect indices (tomography, X-rays, bone-mineral content) with hisotolgic observations in bones; and (5) evaluating remedial countermeasures.

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Alterations in Mineral Metabolism During Weightlessness and Simulated Weightlessness

E. Morey-Holton 44.10.21.04

Research on the influence of gravity on bone turnover and calcium homeostasis is being conducted. The main emphasis is on spaceflight experiments and on a rat model that demonstrates bone loss similar to that seen during spaceflight. Changes in bone formation rates, cellular recruitment, and linear bone growth are being studied. Calcium isotopes (stable and radioactive) are used to assess calcium balance and bone turnover.

References
T.S. Wronski & E.R. Holton, Med. Sci. Sports Exercise *15*, 410 (1983).
W.S. Jee *et al.*, Am. J. Physiol. *244*, R310 (1983).

Human Environmental Physiology

J.E. Greenleaf 44.10.21.05

Research in this laboratory involves understanding mechanisms of adaptation to environmental stresses such as heat, cold, altitude, and acceleration as well as physical exercise. Current studies are focused on the fluid-electrolyte-hormonal aspects that contribute to these adaptations, with special emphasis on the effects of prolonged exercise training on orthostatic tolerance, lower-body positive pressure on fluid-endocrine response, and water immersion on exercise thermoregulation.

References
J.E. Greenleaf, Med. Sci. Sports Exercise *16*, 20 (1984).
J.E. Greenleaf *et al.*, Aviat. Space Environ. Med. *54*, 696 (1983).

Weightlessness Simulation

J.E. Greenleaf L.C. Keil 44.10.21.06

Studies are designed using bed rest and water immersion to investigate mechanisms involved during adaptation to weightlessness. Emphasis is directed to fluid-electrolyte balance and associated hormonal involvement. Current studies will compare fluid-electrolyte-hormonal responses during 12-h bed rest and 12-h immersion periods, investigate the roles of vasopressin and natriuretic factors in the mechanism of natriuresis and diuresis, and continue the study of mechanisms of fluid intake.

References
J.E. Greenleaf & L.C. Keil, J. Appl. Physiol. *55*, 1688 (1983).
V.A. Convertino *et al.*, J. Appl. Physiol. *54*, 508 (1983).

Human Space Medicine

D.J. Goldwater 44.10.21.07

Research is currently directed toward operational medical needs of the Space Shuttle program, such as crew selection, maintaining crew health, optimizing in-flight and reentry performance, minimizing postflight medical probelms, and long-term health follow-up. Studies simulate weightlessness effects on cardiovascular and neuroendocrine systems using bed-rest hypokinesia and water immersion. Specific research opportunities include (1) interaction of age and gender on tolerance to Shuttle reentry; (2) effectiveness of drug countermeasures for weightlessness-induced cariovascular deconditioning, and (3) the role of preflight aerobic conditioning and postflight exercise rehabilitation.

References
D.J. Goldwater & H. Sandler, Aerosp. Med. Assoc. Preprints, 202 (1982).
D.J. Goldwater *et al.*, Physiologist *25* (1982).

Endocrine Regulation of Fluid/Electrolyte Metabolism

L.C. Keil 44.10.21.08

Neuroendocrine regulation of fluid/electrolyte balance is being studied in humans and animals exposed to hypergravity, hyperthermia, and hypokinesia. Studies are currently focused on the effects of these environmental factors on the ADH secretion and the renin-engiotensin system. Basic neuroendocrine mechanisms influencing the release of these hormones are being investigated in animal models using drugs, blocking agents, and brain lesioning.

References
M.L. Jerome *et al.*, Pharmacology *26*, 79 (1983).
L. Keil *et al.*, Neuroendocrinology *37*, 401 (1983).

Intercellular Proteolytic Enzymes

S. Ellis 44.10.21.09

This program is concerned with the identification, isolation, and subcellular localization of intracellular peptides from mammalian tissues. Research is directed to the characterization of proteolytic enzymes from plasma membranes, lysosomes, endoplasmic reticulum, and nuclei, with particular reference to their specific roles in the development of disuse atrophy of muscle and in the post-translational modification, deactivation, and degradation of specific enzymes and peptide hormones.

Muscle Biochemistry

S. Ellis 44.10.21.10

Investigations are directed to the definition of biochemical and physiological mechanisms that trigger the development of atrophic changes in skeletal muscle. The specific areas of research are (1) protein biosynthesis and turnover of skeletal muscle proteins, (2) definition of the enzymatic pathways of muscle protein degradation, (3) the role of neurotrophic influences in modulating the foregoing parameters, and (4) regulation of muscle mass by growth factors.

Reference

H. Popiela & S. Ellis, Develop. Biol. *83*, 266 (1981).

Bioassayable Growth Hormone and Protein Balance

R.E. Grindeland 44.10.21.11

The objective of this task is to determine the contribution of changes in hormone secretion to the muscle wasting of spaceflight. The concentration and effectiveness of several protein anabolic or catabolic hormones are investigated in animals undergoing actual or simulated weightlessness. Special emphasis is directed towarding clarifying the role in protein balance of immunochemically modified growth hormone and bioassayable growth hormone. Specific studies are aimed at characterizing the hormone physiologically, developing a more sensitive assay, and clarifying the hypothalamic regulation of its secretion.

Reference

R.E. Grindeland *et al.*, Physiologist *25*, 262 (1982).

Medical Microbiology and Immunology

A.D. Mandel 44.10.21.12

The microbiological and immunological aspects of long-duration, manned spaceflight are being examined. Studies include the early (preclinical) detection of disease, prevention of transmission of disease, and the effects of prolonged isolation in a sterile environment on the microbial ecology of man and his resistance to infection upon reentry into a normal earth environment.

Reference
G. Sonnenfeld *et al.*, J. Interferon Res. *2*, 467 (1982).

Gravitational Biology

J. Oyama 44.10.21.13

Research is conducted on the physiology and metabolism of mammalian organisms exposed to altered gravitational force fields for short as well as life-long periods of time. Physiological, biochemical, endocrinological, pharmacological, and biotelemetry methods are being used to study the stress responses and adaptations of animals to increased G by means of centrifugation. Reproduction, growth and development, body composition, bone structure, respiratory metabolism, thermoregulation, intermediary glucose metabolism of muscle and brain tissue, neuroendocrine/endocrine function, and aging processes are under investigation.

Reference
C.E. Mondon *et al.*, Am. J. Physiol. *240*, E482 (1981).

Biorhythms

C.M. Winget 44.10.21.14

Research emphasis is on oscillating physiological baselines and temporal dysrhythmias, such as circadian internal desynchronization of neuroendocrine, metabolic, renal, and cardiovascular control mechanisms. Basic physiological mechanisms of the endogenously controlled temporal events in humans and animal models are studied. Rhythm desynchronization of personnel in the Space Shuttle and in earth-orbital laboratories and of translongitudinal travelers is of foremost importance. Biochemical, biotelemetry, and biophysical techniques are used to collect the data.

References
C.A. Walker & C.M. Winget, *Chronopharmacology and Chronotherapeutics* (University of Florida, 1981).
C.M. Winget *et al.*, Neb. Med. J. *65*(11), 303 (1980).

Studies of HZE-Particle Effects on Mammalian Tissue

L.M. Kraft 44.10.21.15

Studies involve several aspects of radiobiology aimed toward an understanding of the effects of HZE (high-Z, high-energy) particles on various mammalian organs and tissues. Irradiation of animals, principally small rodents, is performed at the Bevalac of the Lawrence Berkeley Laboratory, Unviersity of California at Berkeley. Both direct and abscopal (remote) effects are investigated. Specifically, information is sought on the relative biological effectiveness (RBE) of heavy ions, e.g., carbon, neon, argon, and iron, with respect to defined histopathological or physiological endpoints. Morphometric data acquisition and reduction are performed in part by means of computerized image analysis. The purpose is to enable assessment of risk to

atronauts from exposure to cosmic-particle radiation during extended spaceflight.

Mechanisms of Muscle Degradation

C.B. Dolkas 44.10.21.16

Studies are being conducted during hypokinetic (or simulated weightless) states to clarify the role of (1) enzymatic activity, (2) caloric intake, (3) insulin metabolism, and (4) aging on muscle degeneration and its prevention. To investigate these various parameters, infusion-perfusion and receptor-assay techniques are being used. Likewise, noninvasive techniques, such as computer analogs of these and other mechanisms, are being developed.

References

H. Sandler *et al.*, Aviat. Space Environ. Med. *54* (3), 191 (1983).
C.E. Mondon *et al.*, Aviat. Space Environ. Med. *54* (10), 919 (1983).

Ultrastructure Research

D.E. Philpott 44.10.21.17

Research is carried out in the Electron Microscopy Laboratory in the following areas: (1) ultrastructural response of living organisms to the space environment, (2) radiobiological effects of heavy ions, (3) retinal alterations that are due to spaceflight conditions, (4) myocardial tissue response to simulated weightlessness, and (5) aging effects as introduced by HZE radiation.

Reference

D.E. Philpott *et al.*, Elect. Micr. Soc. Amer. *40*, 252 (1982).

Neuroanatomy and Physiology of Vestibular and Motion Sickness

W.R. Mehler N.G. Daunton 44.10.21.18

Research is directed toward understanding the role of sensory-motor interactions in the development of motion sickness and in the process of adaptation to abnormal motion environments. Comparative neuroanatomical and neurophysiological studies of the afferent and efferent connections of the vestibular complex and the vomiting centers are under investigation, and the ultrastructure and histochemistry of areas essential to motion sickness are being studied. Neurophysiological and behavioral methods are used to develop an understanding of the mechanisms underlying adaptation to motion-sickness-inducing environments and to determine the changes in processing of vestibular information that occurs during this adaptation. Pharmacological studies are performed to elucidate neural mechanisms in motion sickness and adaptation and to identify new approaches for the development of antimotion-sickness drugs.

References

J.A. Rubertone *et al.*, Brain Res. *263*, 137 (1983).
N.G. Daunton *et al.*, Brain, BEhav. Evol. *23*, 1 (1983).

Psychophysiology of Space Motion Sickness

P.S. Cowings 44.10.21.19

The Psychophysiological Research Laboratory at Ames is currently engaged in a series of Earth-based investigations designed to detect and treat human physiological disorders resulting from exposure to weightlessness in space. This treatment involves training human subjects to voluntarily control several autonomic responses simultaneously and thereby suppress the effects of environmental stress. The method components are operant conditioning (biofeedback) in combination with attention training, autogenic therapy, and other self-regulatory techniques. The principle application of this work is to develop a preflight training program that should permit crew members to diminish the debilitating effect of the Space Adaptation Sickness Syndrome during actual Space Shuttle missions. Current research programs emphasize the development of instrumentation and/or procedures that enable more detailed investigation of human physiological responses to this type of environmental stress.

References

W.B. Toscano & P.S. Cowings, Aviat., Space Environ. Med. *53*, 449 (1982).
P.S. Cowings & F.V. Malmstron, Flying Safety *40*, 2 (1983).

Perception and Performance in Altered Gravitational-Inertial Fields

M.M. Cohen 44.10.21.20

Experimental studies are concerned with perception and performance using a particular research strategy: the systematic alteration of the gravitational-inertial field in which the perception and performance takes place. It is explicitly assumed that by carefully observing how perception and performance are altered by perturbations of gravitational-inertial forces, it is possible to formulate valuable hypotheses regarding the structure and development of normal perception and perceptual-motor performance, to delineate the range over which normal perception and performance remain unaffected by specific gravitational-inertial inputs, and to describe and predict how various parameters of perception and performance are altered by systematic changes of the gravitational-inertial field. Psychophysical scaling and behavioral-measurement techniques are used to determine thresholds, threshold shifts, adaptation times, measures of perceptual illusions, and changes in psychomotor performance.

Reference

M.M. Cohen, in *Intersensor Perception and Sensory Integration*, R.D. Walk and H.L. Pick, Jr., eds. (Plenum Press, New York, 1981), pp. 175–215.

Studies of Amphibian Embryogenesis in Altered Gravitation Fields

K.A. Souza 44.10.21.21

Amphibian embryogenesis is known to be sensitive to alterations in the magnitude and direction of gravitational force. Research is

conducted to determine the role of gravity during embryonic development and to identify the gravity-dependent processes. The utility of a zero-gravity environment (e.g., in the Space Shuttle) as a toll of embryology is being evaluated, and problems are studied involving the fertilization, development, and rearing of amphibian embryos in a weightless condition.

Aero-Space Human Factors Research Division

Computation Models of Human Vision

A.B. Watson A.J. Ahumada 44.10.09.01

Several decades of research in human vision have provided a firm empirical foundation from which to develop a comprehensive model of human vision. Such a model can predict human sensitivity and discriminability of images that vary spatially, temporally, and with respect to color, location, and image motion. The development of such a model has both theoretical and practical implications. First, since the visual aspect of arbitrarily complex images can be predicted, fundamental notions about human visual function can be tested under strong conditions. Second, contemporary human-machine design problems are so complex that human models will be required increasingly during the design process. A variety of very-high-performance image, graphics, and computation facilities (including Class VI computers) are available to support this research.

Reference

A.B. Watson, in *Physical and Biological Processing of Images*, O.J. Braddock & A.C. Slade, eds. (Springer-Verlag, Berlin, 1983), p.100.

Optimal Visual Displays

A.B. Watson A.J. Ahumada, Jr. D.C. Nagel 44.10.09.02

Visual displays are among the most effective means of providing humans with information. Many kinds of displays are possible: symbolic, imaging, pictorial, alphanumeric, and so on. A principle for effective display design that has not been fully exploited is to match the characteristics of the display to the characteristics of the viewer. This research, supported by more fundamental work on human visual function, seeks to develop design principles for advanced visual displays that are optimal from the human point of view. Display techniques of interest include very large electronic displays, high- and variable-resolution displays, and stereo display techniques. A variety of advanced graphics and display systems are available for use.

Human Performance

D.C. Nagel 44.10.09.03

Laboratory and simulation research is being conducted to identify and develop measures of pilot work load and performance appro-

priate for part-task and full-mission simulation and flight. The initial efforts have been focused on (1) identifying factors that contribute to the subjective experience of work load; (2) developing and testing subjective, physiological, secondary-task, and primary-task measures of work load and performance; (3) developing a predictive methodology for imposing predetermined levels of work load; (4) applying linguistic and video analysis techniques to evaluate the relationship between aircrew interaction and flight task performance; and (5) identifying and classifying errors as a source of work load.

Future areas of additional emphasis will include studying the role of individual differences in work load and performance, the use of model-based structures to characterize the human-performance data obtained in flight and in simulation, and investigating changes in behavior, perception, and performance associated with training. The results of the analytical research are applied to current and future aeronautical and space systems.

Human-Machine Interactions

E.A. Palmer, III 44.10.09.04

A research program is being conducted to develop tools to aid in the design and evaluation of human-computer interfaces to aircraft and spacecraft systems. A current research approach is to view pilots' interactions with the computer as words of an action language and then to apply concepts from linguistics and computer science to the analysis of these action sequences. Planned studies will apply formal grammer to the analyses of a number of interactive systems and attempt to predict features of these designs that are likely to lead to learning difficulties and human errors. Experiments will be conducted to test these predictions. Longer-range plans are to develop computer-aided methods for designing human-machine interfaces and automatically check for compliance with human-factors design guidelines.

Aeronautical Human Factors

J.K. Lauber H.C. Foushee 44.10.09.05

This is a broad, multidiscplinary research program that addresses a variety of human-factors problems and how they affect safety and efficiency in aircraft operations. This research includes studies of applied issues in human-machine systems design (e.g., the potential application of knowledge-based systems and other forms of automation in aircraft cockpit design), development of requirements and methods for human-operator selection and training, examination of factors such as fatigue and circadian dysrhythmia and how they effect human performance during flight operations, and of problems involved in achieving effective small-group performance such as that required for effective flight-crew communication and coordination.

Although many of these issues are generic, much of this research program focuses on vehicle-specific questions in both fixed-wing transport and rotary-wing aircraft.

Reference
R.C. Graeber *et al.*, in *Breakdown in Human Adaptation to Stress*, J. Cullen, J. Siegrist & H.M. Wegmann, eds. (M. Nijhoff, The Hague, 1984), Vol. 1, p. 584.

Helicopter Human Factors

J.K. Lauber D.C. Nagel 44.10.09.06

Helicopters are among the most demanding of all piloted vehicles from an operational point of view. Technological solutions to helicopter human-factors problems, therefore, are being investigated across a wide front. For example, advanced auditory, visual, and tactile display systems are being examined to determine the degree to which they can improve pilot performance and reduce pilot work load and error. Primary current areas of investigation include the use of voice technology (recognition and synthesis), head-up, helmet-mounted, and advanced panel-mounted displays, and advanced multiaxis controllers. Since many of the advanced display and control concepts involve multimode information processing, current studies are also focusing on fundamental issues concerning the pilot's ability to attend to several sources of information and to perform several tasks, all at once. Finally, the role that automation (including artificial intelligence and knowledge-based systems) can play to reduce pilot work load and improve pilot performance is being investigated. The studies are supported both by basic laboratory facilities and part-task and part-mission simulation facilities.

Group Performance Factors in Space Missions

T.A. Tanner 44.10.09.07

The space station and other future space missions will involve relatively long durations; crews of increased heterogeneous expertise and experience, stresses such as confinement, isolation, and danger; and a requirement for high levels of crew performance. Experiences with Earth-based situations show that the maintenance of high levels of performance over long periods under stressful conditions is difficult at best. In order to achieve the goal of assured high performance in the space station, research is needed to develop an integrated model of group performance involving such factors as crew selection and composition, training, organization and management, and the psychology of environmental effects, such as habitat and work-station design. The research will involve both laboratory studies and space-mission simulations.

DRYDEN FLIGHT RESEARCH FACILITY
Directorate of Flight Operations

Flight Support Division

Parameter Identification

K.W. Iliff 44.10.37.01

The identification of model parameters from experimental data is an important factor in the establishment of adequate mathematical models in the analysis and design of aircraft flight systems. Extraction of parameters from aircraft flight tests poses many unique situations for identification by usual methods. Research is required to determine the methods to use and the flight-test techniques that will improve the extraction of data. Two areas are of particular interest. The first is the formulation of mathematical models based on known physical properties suitable for use by standard parameter-estimation techniques. Of particular interest are problems involving unsteady aerodynamics, aircraft performance estimation from dynamic maneuvers, and propulsion system dynamics. The second area is that of mathematical model structure determination through methods in which the physics of the problem are not well understood. These methods should be used in conjunction with engineering judgement. Either general or specific aircraft results are of interest in this area.

Digital Fly-By-Wire Systems

J. Gera 44.10.37.02

Research is being conducted on advanced digital fly-by-wire systems for manned and remotely piloted vehicles. An F-8C with an experimental digital fly-by-wire control system is available for use as an in-flight facility for research in advanced redundancy-management techniques, low-sample rate control, nonlinear digital control laws, optimal trajectory and flight-test-technique developments, distributed and dispersed sensor and processing techniques, and software verification methodology. Ground facilities, including high-fidelity simulations and a unique, remotely piloted, research-vehicle laboratory, are available for experiment design and correlation. Actual flight correlation opportunities exist because of the collocation of these ground and airborne facilities.

Aircraft Aerodynamics at High Angles of Attack

L. Montoya 44.10.37.03

At present, neither analytical techniques nor wind-tunnel testing can account for the nonlinearities produced by the separated flow of flight at high angles of attack. Because of this, opportunities exist for conducting theoretical fluid- and flight-mechanics studies aimed at

extending our knowledge in these areas to the extreme angles of attack that are attainable by presently operational, highly maneuverable aircraft. Studies would encompass the limitations of current techniques, new approaches to incorporating nonlinear behavior, and the effects of vortex flow interactions on incipient stall-departure characteristics. The study would investigate new approaches for aerodynamic modeling by actual correlation of full-scale flight data with wind-tunnel and analytical results.

Integrated Propulsion-Flight Control

F.W. Burcham, Jr. 44.10.37.04

Research is under way to develop integrated propulsion-flight control systems for advanced aircraft, such as supersonic transports, high-performance fighters, vertical/short takeoff and landing aircraft, and hypersonic aircraft. These classes of flight vehicles exhibit strong interactions between propulsion and flight-control systems and can benefit substantially from control integration. Flight tests of an integrated control system are currently under way. Of particular interest is the use of optimal control methods to handle the multiple-input multiple-output nonlinear control problems required for these aircraft.

Handling-Qualities Criteria for Highly Augmented Aircraft

D.T. Berry 44.10.37.05

The emerging state of the art makes it possible to build flight-control systems to meet almost any requirement. However, the cost and complexity of these systems can vary by orders of magnitude as a function of relatively slight differences in design requirements. Thus there is a critical need for reliable design guides and specifications. However, existing design guides and criteria are based on a body of data that has been gathered over a number of years on essentially unaugmented aircraft.

Work is under way at Dryden Flight Research Center to utilize data from aircraft to generate a data base for highly augmented aircraft. These data will be correlated with simulator studies and pilot-in-the-loop-systems analysis using linear and nonlinear techniques. Research in modeling the human pilot will also be undertaken.

Aircraft Flight Control

J. Gera 44.10.37.06

A wide variety of research opportunities exist at Dryden in the area of aircraft flight controls and guidance. Specific topics include envelope limiting or boundary control for high-performance aircraft, control for high angle of attack, control for departure or spin prevention, control of semiautonomous remotely piloted vehicles, interactive control-law-design methodology, and optimal-trajectory,

expert-systems, and flight-test technique development. Dryden uses a variety of advanced aircraft, complemented by high-fidelity real-time ground simulation facilities, to validate, correlate, and explore advanced flight-control and guidance concepts. Both manned aircraft and subscale remotely piloted research vehicles are available to investigate control concepts in the most realistic environment possible.

Real-Time Applications of Expert Systems

J. Gera 44.10.37.07

Research opportunities exist at Ames Dryden for real-time applications of expert systems to both generic flight research problems and high-performance aircraft systems. The specific areas of current interest include (1) failure modes and effects analysis, testing, and on-line monitoring; (2) the so-called pilot's assistant or associate; (3) reconfigurable control systems; and (4) the intent-driven cockpit. This research is based on the advanced research aircraft systems and ground-based flight research facilities available at Ames Dryden.

Index of Research Advisers

Ames Research Center

Telephone inquiries concerning technical details of specific research opportunities may be made of individuals listed below. The area code and exchange are (415) 965.

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Dryden Flight Research Facility

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